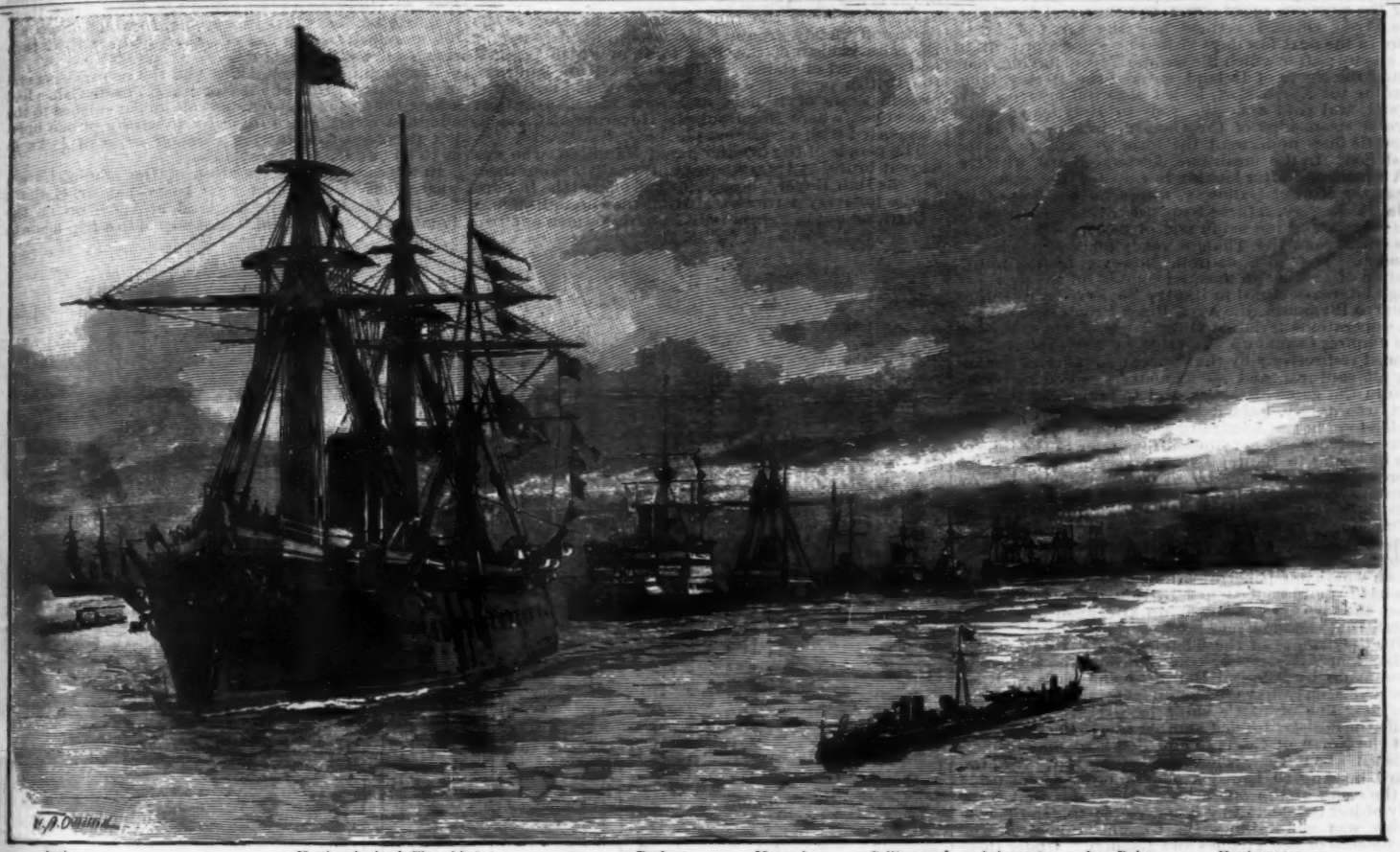
SCIENTIFIC AMERICAN

No. SUPPLEMENT 665

Scientific American Supplement, Vol. XXVI., No. 665.
Scientific American, established 1845.

NEW YORK, SEPTEMBER 29, 1888.

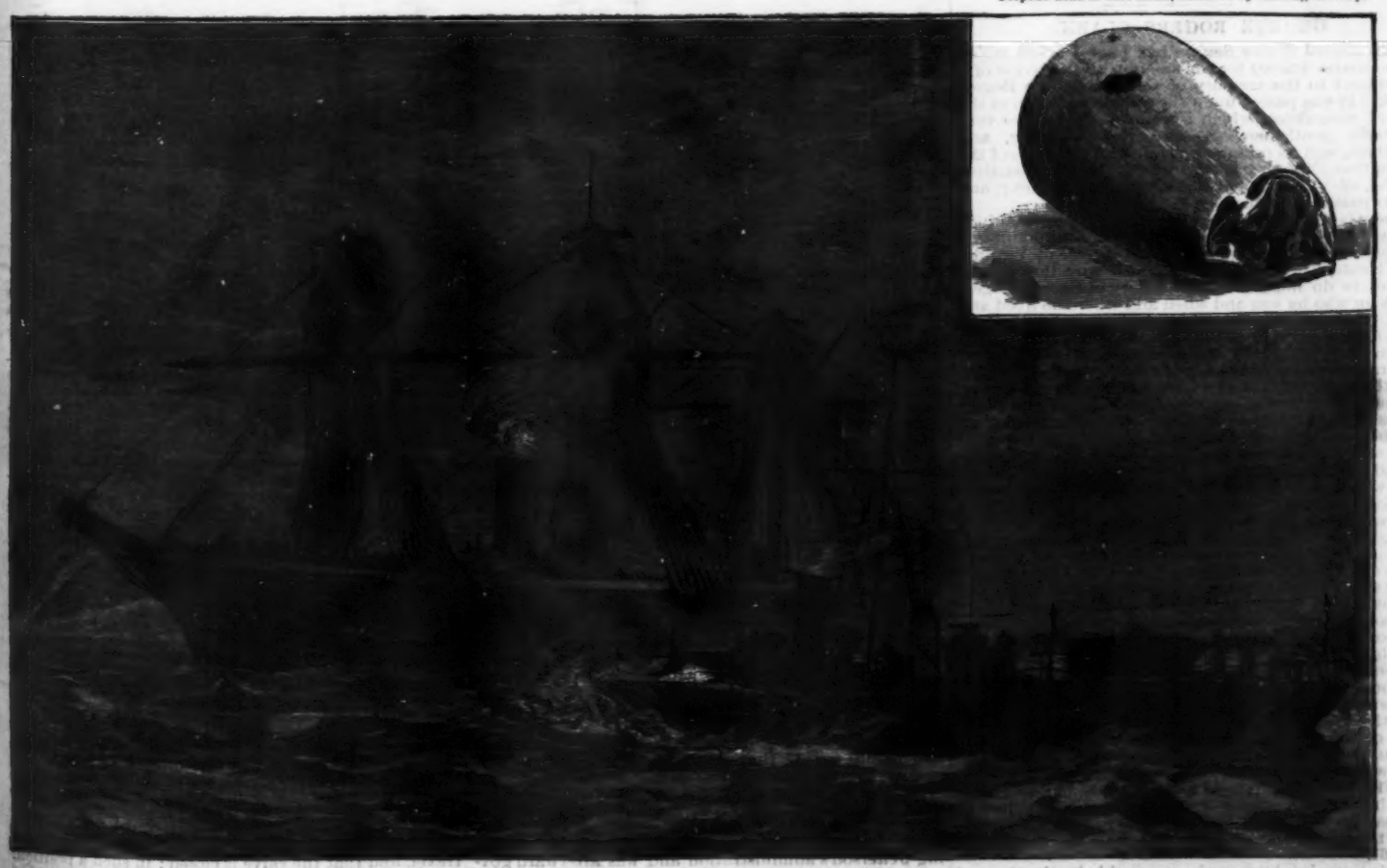
Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.



Active. Northumberland (Flag-ship.) Benbow. Monarch. Collingwood. Hotspur. Agincourt. Conqueror. Iron Duke. Shannon. Neptune. Northampton. Inflexible.

BRITISH NAVAL MANEUVERS—ADMIRAL BAIRD'S SQUADRON IN ORDER OF BATTLE OFF THE MOUTH OF THE THAMES.

Torpedo head of soft metal, flattened by striking the ship.



BRITISH NAVAL MANEUVERS—TORPEDO BOAT No. 76 ATTACKING H. M. S. ACTIVE.

BRITISH NAVAL MANEUVERS.

IN August last many of the British war ships were occupied in performing a series of maneuvers of feigned naval warfare between the "A Squadron," commanded by Admiral Baird, with Admiral Rowley second in command, defending the shores and ports and mercantile vessels of Great Britain, and the "B Squadron," of which Admiral Sir George Tryon was commander-in-chief, while Admiral Fitzroy commanded a separate division. The first division of each squadron, under the immediate command of these two officers, were engaged from July 24 to Aug. 4 in mutually endeavoring to outmaneuver one another in Bantry Bay, where Sir George Tryon occupied the harbor of Berehaven, fortified with booms and submarine mines. At the same time Admiral Fitzroy was blockaded in Lough Swilly, on the coast of Donegal, by Admiral Rowley. Both the blockades were successfully eluded by the "B Squadron" on Aug. 4, or during the previous night; and the shores of Scotland, the Clyde, Oban, Inverness, and the Firth of Forth were in the next few days visited by ships representing an enemy; after which Sir George Tryon, having come round the North of Ireland, entered the Mersey, bombarding the North Fort, levied contributions on Liverpool, and paid a hostile visit to Holyhead; while several steamships of the Cunard, Inman, and other Atlantic lines underwent the form of capture in the Irish Sea. In the meantime, Admiral Baird, with the "A Squadron," after looking in vain for the enemy as far as the Mull of Galloway, where he was joined by Admiral Rowley, returned up the British Channel to the Downs, and formed in line of battle on Aug. 18, at the entrance to the Thames, ready for the defense of London. The "B Squadron," however, having no intention of seeking an unequal combat off the shores of England, reassembled in Bantry Bay, except five ships going to Plymouth, the Ajax, Black Prince, and others. The operations terminated by lapse of time, leaving the umpires to sum up the value of the exploits performed respectively by the opposed squadrons, including all captures, and all maneuvers scored as points won in the game of tactics, and to pronounce the verdict accordingly, guided by a scale before fixed and understood in the Admiralty regulations.

Some of our present illustrations refer to the time of the blockade in Bantry Bay. A sketch by Mr. Wells represents the torpedo boat No. 76, commanded by Lieutenant Campbell, of the "B Squadron," going outside and attacking H. M. S. Active, one of the blockading squadron, which ship was cleverly struck with a torpedo. For this harmless mimic warfare the torpedo heads were specially manufactured of soft metal, which would not penetrate the side of the ship; but the head would be flattened by the stroke, indicating, when the torpedo was fished up afterward out of the water, that the blow had been correctly aimed.

For the defense of the Thames and Medway, which to Londoners is a nearer consideration, the display of force made by Admiral Baird, at the close of these operations, may have been an acceptable spectacle. The long line of battle ships looked very imposing, while the cruisers formed another line to the starboard. But the North of England and Scotland may feel less satisfied about their safety in actual war. Admiral Baird, on Aug. 20, issued a general order commenting on the result of the operations. He states that "the only object considered by him possible under the conditons was maintaining the Channel Squadron and the defense of the Thames and London." Under these conditions, it is now quite evident that our great commercial ports, the Mersey, the Clyde, the Tyne, and the Humber, and all the shores of North Britain lie at the mercy of a naval enemy passing westward of Ireland and from the Atlantic to the North Sea.—*Illustrated London News.*

GEORGE ROGERS CLARK.

THE United States Senate has passed a bill which appropriates $25,000 for the erection at Louisville of a monument to the memory of General George Rogers Clark. It was passed upon the recommendation of the library committee, which is composed of three very scholarly gentlemen, Messrs. Evarts, Hoar, and Voorhees, and its passage was advocated by two of the committee (Mr. Evarts was absent) and by Senators Daniel, of Virginia, and Blackburn, of Kentucky, and it was passed unanimously.

These facts show that the Senate did a proper thing; and yet I doubt whether of the 60,000,000 inhabitants of the United States there are 5,000 outside of Virginia and Kentucky who can even guess why the Senate desires to do honor to the memory of George Rogers Clark, or who he was and when and where he lived and died. Only a few weeks ago (so completely had he been forgotten in the presence of the momentous events which have freighted the memories of the present generation, and of that rush of events which characterizes the civilization of to-day) one of the great morning journals of this city—which is second to none of its rivals in intelligence or intellect—said editorially when the bill was introduced into the Senate that no such man as George Rogers Clark had ever lived.

And yet this forgotten man, this long-buried American, whom the Congress of the United States wisely proposes to rescue from oblivion, was one of the striking figures of our revolutionary epoch, a soldier, a statesman, and a hero; the one man to whose courage and wisdom, to whose soldiership and genius, our country owes all of that splendid domain which lies between the Ohio and the Lakes, all of that rich, and populous, and happy region which embraces the great States of Ohio, Indiana, Illinois, Michigan, and Wisconsin.

George Rogers Clark was born in Albemarle County, Virginia, under the shadow of Monticello, the home of Jefferson, in 1752, twenty years after the birth of Washington. Like that greatest of Americans, and greatest of men, he was a surveyor in his early manhood, and practiced his profession on the upper Ohio, on the borders of the country, which, in 1763, at the end of the *Seven Years War*, was declared to be British territory, and was separated from France forever.

In 1774 he participated in one of those bloody scenes which were the precursors of the revolution, just as the savage warfare in Kansas, eighty years afterward, was the precursor of the great war for the Union in 1861.

This scene has been made memorable by the story of Logan. Young Clark, then 22 years old, was a captain in the force which Gen. Andrew Lewis led against the Indians who were invading Virginia. Lewis himself was a perfect type of the borderer and of an Indian fighter; an Irishman, 44 years of age, strong and brave, and the hero of the frontier. Virginia has perpetuated his form in the bronze statue which forms part of the group which surrounds Washington in Crawford's statue at Richmond.

The Virginians and the Indians met near Point Pleasant, on the Ohio, and after a terrible contest Lewis was victorious, and the last hostile Indian was driven out of Virginia forever.

The next year Clark went to Kentucky, then part of Virginia, and was sent to the convention of that State in 1776. While in Richmond, he was appointed major of the Kentucky militia by Patrick Henry, the first patriot governor of Virginia, and furnished with a small supply of arms and ammunition for the defense of the county of Kentucky.

After expelling the Indians and Tories from "the dark and bloody ground," he determined to conquer the county north of the Ohio, to all of which Virginia had some sort of claim. He first attacked and captured the British posts of Kaskaskia and Cahokia, in the present State of Illinois, and then marched against Vincennes, where Hamilton, the Governor of Canada, was posted with a considerable force.

The people of the frontier hated Hamilton, who was a great brute, and was known universally among them as "the Hair Buyer," because he had offered the Indians a price for every patriot's scalp that they brought him.

Clark set out in February, 1779, with 150 men and two pieces of artillery, and made a march seldom paralleled in history; for the country was then a wilderness, the weather was intensely cold, and twenty miles of the route—between the White and Vincennes—were under water, for the Wabash had overflowed its banks. Nothing daunted, Clark sprang into the freezing stream and was followed by his men. As far as the eye could see, there stretched a nearly unbroken expanse of water. Here and there were spots of dry land, but these were often five miles apart.

Clark and his men nevertheless reached dry land again and were in sight of Vincennes. At sunset they were in front of the place and began the fight. It lasted two days. On the 25th of February, 1779, Hamilton surrendered, and was sent a prisoner to Virginia.

Clark reaped all the fruits of this victory, conquered all of the country between the Ohio and the Lakes, and held possession of it in the name of Virginia, whose officer he was, and who furnished the men and the means for making the conquest.

When the treaty of peace between Great Britain and the colonies was made in 1783, the American commissioners claimed this territory on the ground that it had been conquered and was held by Clark. The British commissioners insisted for a while that the Ohio River should be the boundary between the two countries, but they finally admitted that Gen. Clark had conquered the country north of the Ohio, and was in undisputed military possession of it at the time of the negotiation, and finally agreed that it therefore belonged to this country.

He died in 1818, at Louisville, and there his body still lies buried.

He was the eldest brother of that William Clark who, with Meriwether Lewis, crossed the continent during Jefferson's administration and was afterward governor of Missouri.—*The Globe.*

THE HYDRAULIC ELEVATOR AT LES FONTINETTES.

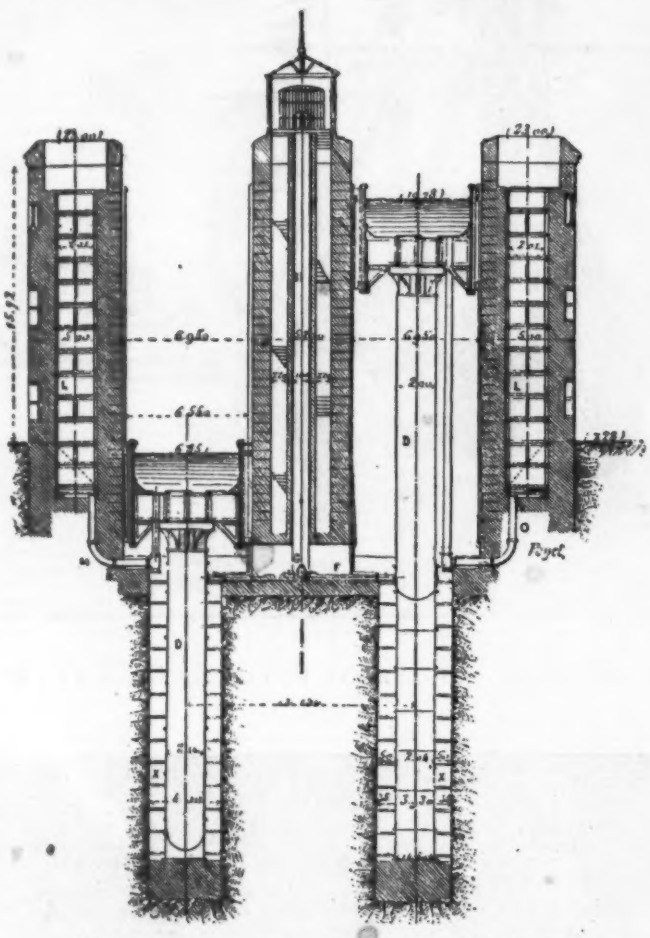
ON the 8th of July, 1888, the Minister of Public Works went to the Department of the North in order to be present at the inauguration of the greatest hydraulic work ever constructed in France—the elevator at Les Fontinettes, near St. Omer, on the Neuffosse Canal.

The Neuffosse Canal, which was begun by Louis XIV., connects the ports of Calais, Gravelines and Dunkerque with the system of canals of the North. All the boats coming from the great ports of the Strait of Calais are obliged to pass through this common section in order to reach Lille or Paris.

The traffic on this canal amounts to 800,000 tons per annum, and is destined to become greater when the great work undertaken to extend the ports of Dunkerque and Calais is finished. On this section, at 2½ miles from St. Omer, at a place called Les Fontinettes, there is a string of locks, five in number, at which boats are often obliged to stop five or six days before their turn comes to pass through.

The chambers of commerce and the councils-general of the departments of the North and Pas-de Calais had a long time back pointed out this inconvenience to the administration, which, in order to satisfy public opinion, proposed to construct a second series of locks, so as to let two boats pass at once.

In the interim, the attention of the administration was called to an elevator for boats that Mr. E. Clark had just constructed in England, at Anderton, on the Trent and Mersey Canal. As a sequel to a trip made to England by Mr. Bertin, government engineer in chief, the Anderton system was adopted as a substitute for the proposed second series of locks. To this effect a contract was made by the administration with Mr. Clark and the Cail establishment.



FONTINETTES ELEVATOR—SECTIONAL VIEW.

According to the contract, the Cail works were themselves to make detailed drawings of all the parts, the mechanical as well as the masonry.

If we compare the dimensions of the Anderton elevator, which is designed for 80 ton boats, with the one at Les Fontinettes, which lifts boats of 300 tons, we shall get an idea of the immense difficulties that the Cail works met with. It is, therefore, a great honor to this establishment to have succeeded in the difficult enterprise.

The apparatus is essentially formed of two portions of a canal in plate iron, called lock chambers. Each of these rests at its center upon the head of a piston which works in the cylinder of a hydraulic press, placed in the center of a well. The two presses communicate through a pipe provided with a sliding valve which permits of isolating or connecting them. When the valve is open, we have a true hydrostatic balance. If one of the chambers is more heavily loaded than the other, it descends and forces the lighter one to ascend. Such is the apparatus as a whole.

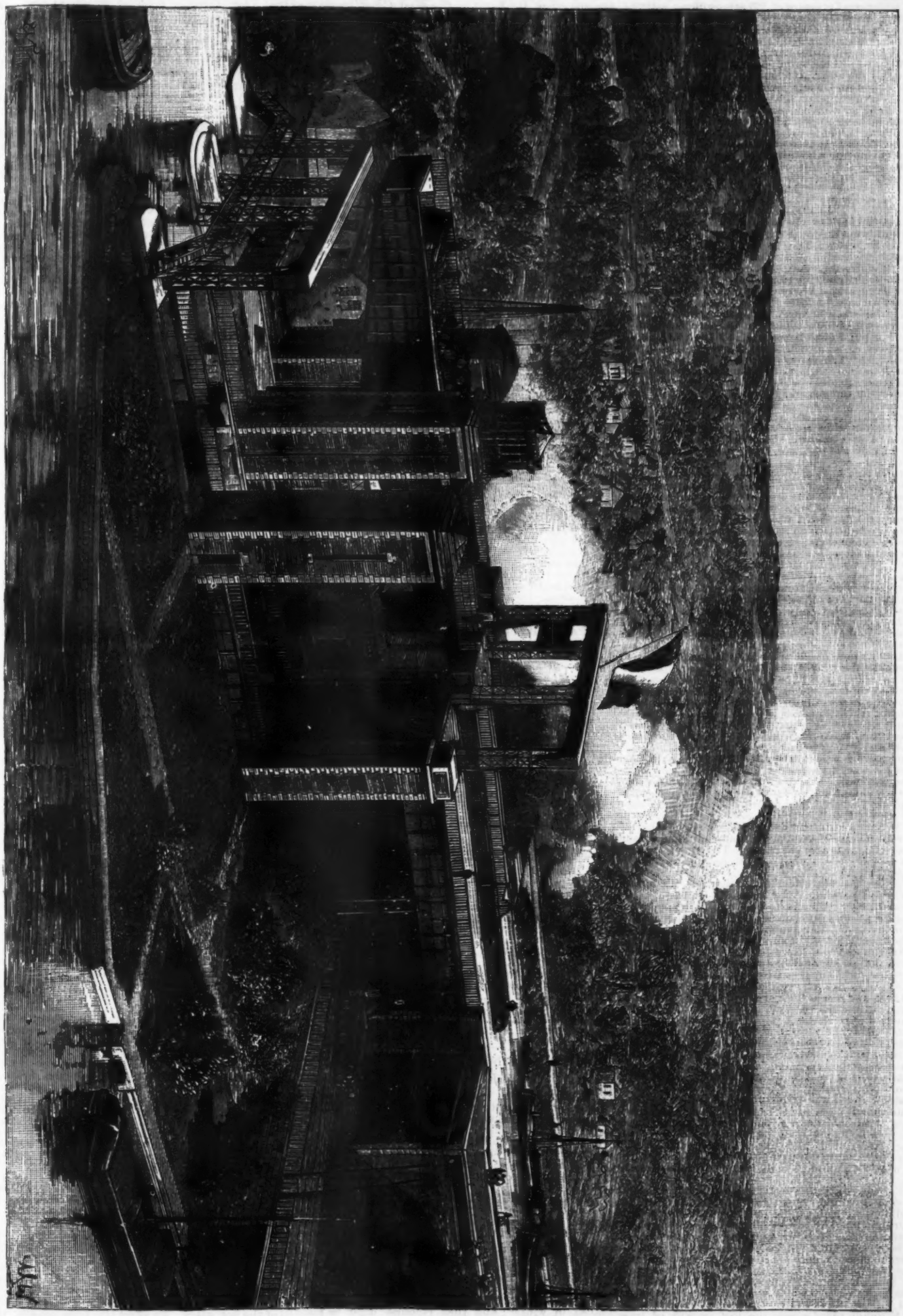
The stroke of the pistons is equal to the difference of level between the canals—say 43 feet. The chambers are of sufficient size to receive the largest boats that navigate the canals of the North. Their length is 130 feet, their width 19, and their depth 7. The weight of such a chamber, full of water, is 800 tons, and a mass of 1,600 tons is therefore in motion at every maneuver.

Let us suppose the piston of one of the presses is at the top and that of the other at the bottom of its travel, and that the valve is closed; in such a position, the chamber on the head of the piston that is out of

its press will be on a level with the upper canal, while the other will be on a level with the lower one. Let us introduce a boat into each of the chambers and close their gates and those of the canals, so as to isolate the chambers completely, and we shall not affect the equilibrium of the system, which will remain immovable. If, now, we open the sliding valve, the upper chamber will descend and the lower will rise, and this motion will proceed until the two chambers are on the same level. At this instant, the two chambers will be at the center of their travel and in equilibrium upon their presses, which contain the same height of water.

In order to force the chamber that was on a level with the upper reach to descend, instead of giving it the same quantity of water as is given the lower chamber, it is supercharged in the beginning with a weight of water equal to that contained in a press, so that, instead of stopping in the middle of its travel, it continues its motion until it reaches the level of the lower canal.

There is nothing particularly remarkable about the construction of the chambers. They are metallic frames whose various parts are calculated according to the well known rules of the resistance of materials. The presses, on the contrary, are double the size of the largest ones in existence. They are 55 feet in height and 6½ in diameter, and the internal pressure that they have to resist is 27 atmospheres. There were no known precedents. The cast iron presses of the Anderton elevator had already broken in normal operation without there being any possibility of attributing the event to a false maneuver or a fatuitous accident. So a new solution had to be found. The Cail establishment solved the difficulty by an ingenious process, which it has patented, and which consists in forming the presses of rolled steel rings superposed, and set into a groove



THE HYDRAULIC CANAL BOAT ELEVATOR AT LES FONTINETTES.

in order to prevent them from moving laterally. In order to render the interior of the press absolutely tight, it is lined with copper $\frac{1}{16}$ inch thick, in a single piece applied by a mallet against the sides. The water under pressure therefore meets no joint capable of giving it exit. A section of one of these presses has supported an internal pressure of 175 atmospheres without distortion.

All the maneuvers of the gates are effected by means of hydraulic presses in less than a minute. The passage of a boat, which formerly required two hours, is now effected in three minutes, and during the three months that the apparatus has been in operation more than two thousand boats have been transferred from one reach to the other.

We should add, in conclusion, that it results from data that we have obtained from a reliable source, that the success of the enterprise should, in great part, be attributed to Mr. A. Barbet, engineer in chief of the Cail establishment, who has given proof of a remarkable intelligence and initiative in the mechanical part of the work.—*L'Illustration.*

FOUR HUNDRED MILES IN EIGHT HOURS.

IT is not the fault of the daily press if the fast West Coast train from Euston to Edinburgh is unpopular, says *The Engineer*. The 10 A. M. train runs from Edinburgh to Euston, 400 miles, in eight hours, and editors and correspondents have alike exhausted their powers in describing this run as something beyond expression dangerous. We have been told of a fireman paralyzed with fear on the running board, of the distress of drivers and firemen, while the perils incurred by the passengers are enough to appal the stoutest heart. The plain fact, divested of all this terrorizing romance, is that a more agreeable journey it is impossible to make. The railway carriages are perfection; the road is as good as it can be; and the utmost care and vigilance are observed to render the trip safe. No portion of the run is made at speeds higher than have heretofore been common enough. The entire difference lies in the circumstance that there is less slow running and fewer stops than usual. Nothing will make the truth plainer than the statement which we append of the run of the 10 A. M. from Euston, on Friday, August 17.

The train consisted of four eight-wheeled composite coaches, weighing about 80 tons, including passengers and their luggage. There were fourteen compartments and eight coupes, the luggage being carried in lockers, as is usual on the North-Western. The train was the joint stock of the London and North-Western and the Caledonian companies, fitted throughout with the double automatic vacuum and Westinghouse brake system. First, second, and third class passengers are carried by these trains at the usual fares.

The train was taken from Euston to Crewe without a stop by the Waverley, an outside cylinder single wheel engine of the Lady of the Lake class, built in 1863. It is noteworthy that a locomotive twenty-five years old should be found perfectly adapted for this latest development of railway traveling. In the annexed table the times of passing the stations named are given to the nearest half minute, which is sufficiently accurate. It will be seen that 10 minutes were occupied in running the 5½ miles to Willesden, which includes the heavy climb to Chalk Farm, and for a long period the train was steadily behind the sixty-mile-an-hour rate by about 8 minutes, the thirtieth mile post from Euston being passed exactly 38 minutes after 10; the fifty mile post 57 minutes after 10; and the sixty mile post 90 minutes after 10. We have given in different places the fastest quarter miles run. The quarter mile was never done in less than 14 seconds on this section, or at the rate of 64·26 miles an hour, and this very rarely. The fastest bit run was perhaps from Tamworth to Lichfield, 8 miles in 7 minutes, or at 68·58 miles an hour nearly. The eight-wheeled coach ran so steadily that there was no oscillation, and a wonderful absence of noise. The train reached Crewe at 12·57, the average speed having been 53·57 miles per hour.

At Crewe the Waverley was exchanged for a new engine, the Lightning, built from Mr. Webb's designs at Crewe in 1888. This is a four-coupled inside cylinder engine, of admirable design and proportions. It is noteworthy that the compound system is not used for this flying express. The train left Crewe at 1·2 P. M. The run to Preston was made at a permanently high but not excessive velocity, 51 miles in 57 minutes, or at the rate of 53·6 miles per hour. A stop of twenty minutes is allowed at Preston for dinner. The train left at 2·22, and ran at high speed until the incline was reached, but up this bank from Tebay to Thorpe, on the steepest part of the incline, 1 in 75, the Lightning took its load at the rate of a quarter of a mile in 28 seconds—31·8 miles per hour. On the falling gradient from Shap, however, some very fast time was made. The highest velocity attained was a quarter of a mile in a little over 13 seconds, or at the rate of 69·24 miles an hour. But even at this speed there was no violent oscillation, and it was difficult to believe that the train was running at more than the normal 60 miles an hour. Carlisle was reached at 4 P. M., 3 minutes before time, 98 minutes being required to run 90 miles, or at the average speed of 55 miles per hour. It will be seen that on this run, as on that from Euston to Crewe, the train was just 8 minutes behind the sixty-miles-an-hour rate.

At Carlisle the train was handed over to the Caledonian company, and taken thence to Edinburgh by the splendid Caledonian engine built from the designs of Mr. Drummond, and already illustrated in our pages. This engine runs up hill and down dale with the running lever in the first notch from the center, and is a wonderful climber, doing half a mile on the worst part of the Beattock bank in 45 seconds, or at the rate of forty miles an hour, while between Lockerlie and Whamphray a quarter mile was run in 13 seconds, and a half mile in 28 seconds. In several places the line runs through plantations, the low growth of trees, aspens or alders, so close that their boughs almost brushed the carriage windows as the train rushed past at high speed. These trees were bent in the opposite direction by the fierce blast of air moving in the opposite direction to fill up the vacuum left by the train behind it. The train steamed into the central station, Edinburgh, at 5:57, or three minutes before its time, 109 minutes for 101 miles, or at the rate of 55·5 miles per hour. Here again it will be seen that the train was just nine miles behind the sixty-miles-an-hour rate.

As to the policy of running races on the East and West Coast lines, we have nothing to say. That is an affair for the companies to settle. But we have no hesitation in saying that so far as safety and comfort are concerned, the flight on the West Coast leaves nothing to be desired. The run is a perfect triumph of skill, and it is quite certain that the utmost has not been done that can be accomplished. Yet, after all, is it really worth while to save half an hour in the run of four hundred miles? We very much doubt that it is.

The sympathy extended by a section of the public to the drivers and firemen is about as well placed as it would be were it expended on the jockeys who ride the Derby. To drive one of the flying expresses is the highest pinnacle of honor to which a driver can attain, and not the least enjoyable moment of a man's life is that when he draws up to the platform with three minutes' time to spare, and finds himself and his engine the center of attraction for an admiring crowd.

Station.	Miles from Euston.	Time A. M. h.	m.
Euston	0	10	0
Willesden	5½	10	10
Harrow	11½	10	16½
Pinner	13½	10	18½
Bushey	16	10	21½
King's Langley	21	10	27
Checked for platelayers	..	..	..
Boxmoor	24½	10	33
Thirty mile post	30	10	38
Tring	31½	10	39½
One mile run in 58 seconds	..	..	..
Forty mile post	40	10	48
Bletchley	46½	10	54½
Fifty mile post	50	10	57
Roade	60	11	8
Blisworth	63	11	11½
Weedon	69½	11	18
Eighty mile post	80	11	30
Checked by signals	..	..	..
Rugby	82½	11	34
Nuneaton	97	11	50
Atherstone	102¼	11	55
		P. M.	
Tamworth	110	12	1½
Lichfield	118	12	8½
Rugeley	124½	12	16½
Colwich	127	12	20
Stafford, slowed through	133½	12	28½
146 mile post	146	12	43¼
Madeley	150	12	48
One mile in 55 seconds	..	..	..
Slowed for Crewe	158	12	57
Stopped	..	12	58
Started	..	1	2
Hartford	169¾	1	16
Acton Bridge	172¾	1	19
Preston Brook	176½	1	23½
Warrington	182	1	28½
Wigan	194	1	43
Euxton	204½	1	52½
Preston, arrive	209	1	59
Preston, depart	..	2	22
Lancaster	230	2	40
Milnethorpe	244	2	52½
Oxenholme	249¼	3	4½
Grayrigg	..	3	14
Tebay	262	3	20
Up 1 in 75, ¼ mile in 28 seconds	..	..	..
Shap	271	3	31½
¼ in 14 sec., ¼ in 13 sec	..	..	..
Penrith	281¼	3	42
Calthwaite	..	3	50
Southwaite	..	3	53
¼ mile in 14 seconds	..	..	..
Wreay	..	3	55½
¼ mile 13 sec., ¼ mile 13 sec.	..	..	..
Carlisle, arrive, 3 min. before time	299½	4	0½
Carlisle, depart	..	4	8½
Kirkpatrick	312¾	4	22½
Ecclefechan	319	4	29
Lockerbie	325¾	4	35
¼ mile in 13 sec., ½ mile 28 sec.	..	..	..
Wamphray	334	4	42½
¼ mile in 14 sec.	..	..	..
Beattock	339¼	4	47½
¼ miles, 17 sec., 20 sec., 21 sec.	..	..	..
½ mile, 45 seconds	..	..	..
Elvanfoot	352	5	4½
Abington	357¼	5	9
Carstairs	373	5	25
Edinburgh	400	5	57

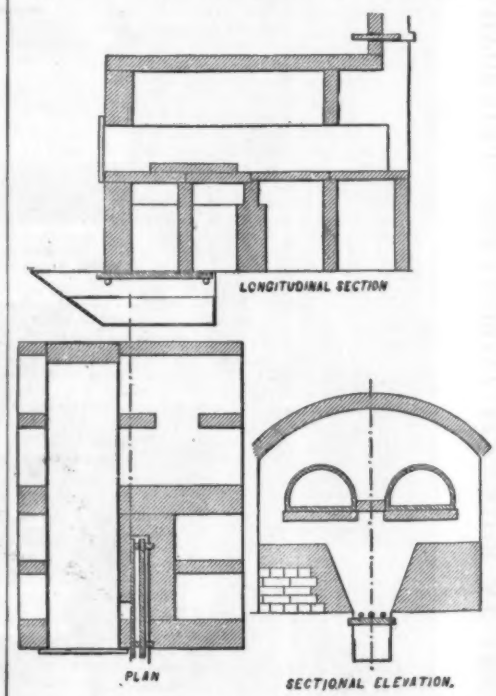
RETORT SETTING FOR SMALL GAS WORKS.*

By J. ROBB, Limavady.

IN attempting to lay before you a short account of a system of retort setting adapted to meet the wants of a great many managers of small gas works in Ireland, who, like myself, have to struggle against badly constructed works, small consumption during the summer, and very limited funds, I hope those who have more experience in these matters than I have will deal leniently with any blunders I may make in the literary part of my work.

During the period I have lived in Ireland, I have been surprised at the yield of gas obtained per ton of coal in small works; some returns showing as little as 3,000 cubic feet on the consumers' meters, while a great many average only 7,000 to 8,000 cubic feet on the station meters. Now, in looking for the cause of this, I find much of the evil is due to the want of summer consumption. The retorts are kept going all through the summer, and very often only charged once in two days. This style of working swallows up all the coke saved in winter; and then recourse must be had to coal. But why should this be so? Simply because if the heat on the retorts is once let down, it cannot be brought up again in anything less than a week or a fortnight. This may seem strange to some of you; but still it is a fact, and it is not to be wondered at, when we see the class of men who have hitherto had charge of these works. The salaries offered in some cases are not sufficient to procure proper food; and working as they do from six in the morning until twelve and occasionally later at night, there is no time for thought, and no money to spare to acquire knowledge from the experiences of their more favored brethren. At the same time a lot of useless, nominal officials have been drawing salaries, sometimes twice and even three times as much as that of the manager. If these salaries were given to the manager, who with a little labor assistance could do all the work, he, having a little time at his disposal, would be able to improve himself; and, with the aid of an association like this, the small works in Ireland would soon bear comparison with those similarly circumstanced in England or in Scotland, and also prove more profitable for both producer and consumer.

Having to meet difficulties in carbonizing of the kind just described, I will simply relate how I got rid of them. When I took charge of the Limavady works about two years ago, out of nine retorts I had none that would work to my satisfaction. During good, dry, mild weather, I could get a heat sufficient to yield 9,000 cubic feet of gas per ton; but whenever cold, wet weather set in, away went my heats, giving a correspondingly low return, of about 8,000 cubic feet per ton, and requiring even then an expenditure of fuel equal to 90 per cent. of the coke made. In fact, it was the old story of the furnace white and the retorts little more than red. The sudden drop in the temperature in wet weather was caused by the bench being built close up to a 14 inch outside wall, and the flues too small. To save the heat lost through the back wall at that time was impossible; but I determined to improve my retort settings if possible. With a view to carrying out this purpose, I looked over all the styles of retort settings I could think of, and consulted all the books and journals I could lay my hands on; but I could find very little that seemed just to suit my case. However,



I got as much general information as led me to see that, through the smallness of my nostrils and flues, and the want of a proper mixing chamber for the gases, I was losing more than half the heating power of my fuel, as, instead of getting the theoretical 7,000 units of heat due to the combustion of coke to carbonic acid, I was only getting in the oven the 2,400 units due to its combustion to carbonic oxide. I therefore concluded that the oven ought to have a mixing chamber sufficiently large to allow the complete combustion to carbonic acid to take place before the gases circulated through the setting, and then have such an arrangement of flues as would utilize the gases as much as possible. My idea was to get the greatest heat at the front of the bed, and then by a zigzag course to extract the heat—the one chamber to act as an economizer to the other—and so keep up an equal heat along the retort. To find the capacity of my mixing chamber, I measured the air spaces of my fire bars. I have four air spaces, each 21 inches long by 1 inch broad, which is exactly 84 square inches. The most economical velocity for gases is said to be 60 feet per minute; and my coke space was 1 foot deep. I then calculated thus: Allowing, for practical purposes, an expansion of 1 cubic foot per degree Fahr. of heat generated for every 500 cubic feet of air entering the fire, and, as air absorbs heat very rapidly and just as rapidly gives it up, assuming that it attains a temperature of 500° Fahr. in its passage through the coke, and that the temperature on complete combustion to carbonic acid is 4,500°, then 4,500—500 = 4,000 cubic feet due to expansion, *plus* the 500 cubic feet entering = 4,500 cubic feet per 500 cubic feet, which is equal to 9 cubic feet per foot of air entering the furnace. But my air entrance was not 1 foot, but 84 square inches; and this, calculated to a velocity of 60 feet per minute, gives 3 cubic feet as the size of the mixing chamber (independent of the coke bed), which will allow the complete change to carbonic acid to take place.

The next point to be considered was the circulation of the hot gases. To effect this economically, the flues must be neither too large nor too small; so by simply measuring their length and breadth and distributing them into 3 cubic feet, and having no part contracted, except at the entrance into the main flue (and that only by the damper), I considered that the oven would be certain to heat up to about the full calculation, and if the flues were evenly divided, an equal heat would be obtained all through. To test this rule practically,

* A paper recently read before the North of Ireland Association of Gas Managers, at Lisburn.

I embraced an opportunity which presented itself. I had a double bed of iron retorts, which had not been in use for a number of years, owing to difficulties experienced in getting them to work. Last autumn I took them out, and, finding they were new, reset them in accordance with the principle I have just tried to explain; and, in order to meet the difficulty of the back wall, I built my flues vertically. I divided the oven into three compartments, the first division wall being placed immediately at the end of the furnace bars, and built up the coke bed to a thickness of 14 inches, the remainder 4½ inches, and the second wall 4½ inches all through. The retorts are set only 6 inches apart; and a tile covers this from the first division wall to about 6 inches of the front wall of the oven. The flame from the furnace travels under the bottoms of the retorts, up the sides of the first division, down the sides and under the bottom of the second division, on to the third division, which ascends the same as the first to the damper, which is on the top of the arch, where the waste gases escape into the main flue.

I have now arrived at the most important point in my paper, viz., the practical results. This oven was started on Oct. 1, 1887, and a separate account of the working was kept until March 1, 1888. Owing to my storage being very small, I had to damp down every Sunday, which was somewhat of a disadvantage. The retorts are ⏢ shaped, 18 in. by 13 in. by 7 ft. 6 in. long; and the coal used was Arley mine. There was no exhauster; and the back pressure was 6 inches. From date to date, they carbonized 130 tons of coal, giving 1,298,300 cubic feet of gas; being 9,980 cubic feet per ton. The largest yield of gas obtained in 24 hours was on December 18—being 13,900 cubic feet; and the average make was 6,000 cubic feet per mouthpiece per 24 hours. They returned in coke 4,700 bushels, out of which we sold 2,300 bushels. This shows 50 per cent. of the coke made used as fuel; but the same furnace would have heated six retorts. Our revenue from this source was increased about 200 per cent. Another important matter is that the furnace heats up to carbonizing point in twelve hours, if standing over for a lengthened period; and if from Saturday evening till about ten o'clock on Sunday night, four hours will bring it up to carbonizing heat. There is no difficulty in getting up the heat; on the contrary, we had to use very great caution, and damp down for half an hour at the end of every three hours before charging. After all, one of the sides melted; but, thanks to the use of Sellars' cement, when it had been repaired it was as good as ever.

After seeing the success of this setting, I erected a single bed of retorts on the same principle, following the same rule, and was rewarded with like success. Of course, the saving in coke is not the same, as I have often to damp down for three and four days together; but what I save when working (which is about 15 per cent.) restarts the oven. I am erecting a bed of three fire clay retorts on the same principle; so I shall learn the adaptability of the rule to them also.

I hope this simple effort to help my brethren in small works will meet with their approval, and that we, in Ireland, may soon be able to stand comparison with similar works across the water. Seeing that the majority of the works in Ireland make from 1 to 3 million cubic feet of gas per annum, I hope it will also awaken a desire in all the members of this association to aid them.

REGENERATIVE FURNACES FOR SMALL GAS WORKS.

By JOHN SMITH, of Rosewell.

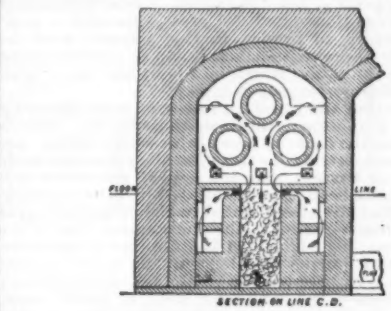
IN the month of July last, I constructed a regenerative furnace at the Rosewell Gas Works, which is still at work, and is giving full satisfaction. The furnace in question is adapted to a setting of three retorts; and as is generally the case, the first operation was to excavate under the oven and in the floor to the depth of 3½ feet, and to underbuild the side walls of the oven. The bottom of this excavation having been laid with 3 inch pavement brick bedded in lime, the foundation of the flues and producer was commenced. The latter is placed inside the oven under the front of the retorts, and is 2 feet square inside and 3½ feet deep. The flues—four in number and 9 in. by 9 in. square—occupy the rest of the space, and extend 3 feet outside the back of the oven, where they are carried to the chimney by a cross flue. These flues were covered with 3 inch checked covers; and another set of flues commenced on the top of them, and covered up in the same manner. A third set of flues was built, and covered up the same way; this last covering forming the bed of the oven.

The top and bottom sets of flues are for the waste heat passing from the oven to the chimney; and the middle set is for the heated air. The producer being built with these is now 3½ feet deep; a hole 15 in. by 15 in. being left at the bottom for cleaning it out. The air for the hot air flues is admitted at the back of the regenerator, and is carried forward by two 4 inch fire clay pipes to nearly the front end of the two center air flues. It goes back outside these pipes, but still in the two center flues, and returns to the front in the two outside air flues, entering the top of the producer by three ports at each side. The two fire clay pipes are used for the purpose of carrying the air to the starting point; there being no other means of admitting the air to the front end of the two center flues. The gases rising from the producer go into combustion with the heated air, and pass up the front portion of the retorts, over a middle wall, down the back portion, then enter the upper set of flues, travel forward, descend to the lower set of flues, and flow outward (as before stated) to the cross flue that leads to the chimney. The upper door of the producer consists of an iron frame 11 inches square inside, and bolted to two brick cheeks; the whole fitting into the angle formed where the front wall and floor meet. A brick to fit this door, bolted to a piece of sheet iron, serves as a cover, and can be lifted off and on when required.

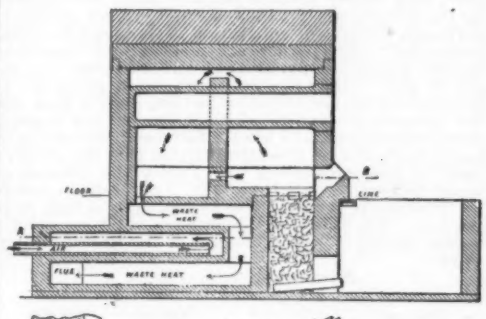
The producer is filled by applying a scoop to the mouth of the retort when drawing, and is cleaned out from below every 24 hours; an excavation having been make in the floor for that purpose, which is covered over with a piece of sheet iron 6 feet long, 3 feet wide, ⅛ inch thick, and on the inside of which three pieces of angle iron are riveted across to give it strength. The primary air is admitted at the door at which the producer is cleaned out. There being no fire bars and no side holes for the admission of air, a piece of 4 inch cast iron pipe, about 2 feet long, is laid down with one end sticking out at the door, the other reaching nearly to the back of the producer, and carrying a portion of the air to that point.

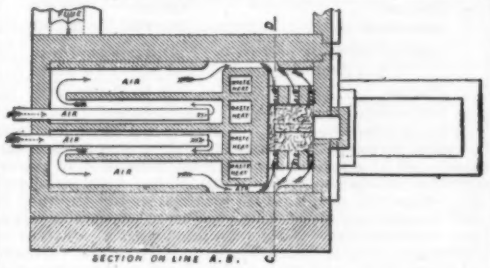
This pipe also serves another useful purpose. Having no steam to keep the bottom of the producer cool, I use water for that purpose; and by allowing it to enter the pipe at something between a drop and a run, it is by the heat immediately converted into steam, and answers the purpose admirably. The distance the heated air has to travel is about 21 feet; but, the flues being large for the small quantity of air required, it travels very slowly, and before reaching the producer is nearly as hot as the inside of the oven. The size of the flues for the waste heat—four in number and each 9 in. by 9 in. square—may seem to be large for the size of the oven; and I have no doubt they would do if they were smaller.

This, however, was the size which was most convenient for me, and I thought it best to err on the safe side; for if at any point the flues are contracted, intense heat, choking up, and destruction to the brickwork is generally the result. In the construction of this furnace, I have taken a slight departure from any I have seen or heard of—that is, in making the horizontal part of the building the conducting partition, or the partition between the waste heat and the heated air. My reasons for doing so are these: The vertical portion of the building has to be of some strength, because it is upon this that the whole structure rests;



SECTION ON LINE C.D.





SECTION ON LINE A.B.

and, there being no stress upon the horizontal part, it can be made an inch or two thinner, and therefore there is much less of that good non-conductor—brick—between the two. The horizontal part, which consists of covers, also makes the isolation between the flues more complete. Another departure from the usual method is in filling the whole space under the oven with flues, and not leaving a vacant space, as is usually done. When the producer is placed inside a small oven, it and the side walls occupy nearly 4 feet. The space, therefore, left for the flues is very limited. In this furnace I have dispensed with flues at the side of the producer, but have used up all the rest of the space for that purpose.

This furnace was lighted in August last; and is still in operation, giving general satisfaction. Some things about it seem to me rather strange. For instance, I have read about it being possible to regulate the secondary air supply by looking into the oven and judging by the appearance of the flame. I had pictured to myself the gas rising black from the fuel, and going into flame—Bunsen burner like—when it met the hot air. In this I was disappointed. It is true that when the charge is newly drawn, there is some flame, and you can see the combustion taking place at the air ports; but, generally speaking, there is no flame at all to be seen. Still the heat kept increasing, until it had to be checked by the damper. What then could be keeping up the heat? It could not be the hot air passing through the fuel, as in the old fireplace; for the air is admitted on the top of the fuel. I have no doubt most of the gentlemen here know what was puzzling me, and what I afterward found out for myself—viz., that the blue flame of a Bunsen burner, when placed inside a fire or red hot oven, entirely disappears; and although still there, does its work invisibly. As far, then, as my experience goes, you cannot well regulate the quantity of air by sight, but must judge by results; and in my case the best results were obtained by an opening of two square inches in each of the pipes at the back of the regenerator.

At first I cleaned out all the ashes in the producer every morning. By doing this a good deal of heat was lost, as it took the fire about two hours before it was at its full strength again. Latterly, I found it better to clean out only what was lying black at the bottom; there being generally a quantity of red clinkers sticking upon the sides, and often bridges right across near the top. A few strokes from the steel bar from above sent the whole to the bottom, and formed a much better foundation for the fresh fuel than the clean bottom of the producer. If fire bars are used, this might be different. The clinkers are sometimes rather hard to remove if the water is neglected, when the heat is very high.

A small quantity of spent shale, however, drawn from the retorts along with the coke, was found to be an excellent thing for preventing clinkers being formed. The fire is damped down at night for about seven hours, during which time there is some loss of heat, but nothing like what would be with the old fires. At the point where the waste heat first enters the flues, there is an accumulation of dust three inches deep; otherwise the flues are as clean as at the commencement. I attribute this deposit to the fact that I use dross to some extent for firing. The brickwork does not appear to be affected in the slightest, although the heat was sometimes so intense that I was afraid to look into it, and as far as I can judge from it at present, would last for a number of years.

And now, as to the important question of economy. Would the saving effected compensate for the first outlay? In my case the saving is very great; but there are special circumstances to take into account. In the first place, the gas works under my charge are close to the Whitehall Fire Clay Works, where the best of material can be had at a moderate rate—the cost of carriage being almost *nil*. The whole cost of this furnace amounted to only £8. In the next place, I use shale to a large extent for making gas, from which there is no coke; and I have therefore to use a large quantity of dross. Formerly I required to have two ovens going for five months of the year; whereas, with the improved heat working off the charge in three hours when it used to take four hours, I can now do with one oven going. The result of the whole is that, whereas formerly I used 18 tons of dross per month, I now only use 3 tons; the coke from one of the retorts, which is charged with splint, being nearly sufficient to keep up the heat. But, as I said before, this is partly due to special circumstances; and the saving is not so much in the summer time. There is also some saving of labor, as the fire requires less attention.

In this furnace, although I had what appeared to me to be feasible reasons for departing from the usual mode of construction, I do not claim to have constructed a better furnace than any one else. It does its work well, and gives no trouble whatever; but that may only go to show how the same end may be accomplished in many different ways. Had I been less favorably situated, I might not have been justified in going the length I have done. More especially was I convinced of this when seeing Mr. Turnbull's furnace at Lauder in April last. It does its work beautifully; is simplicity in itself; and would not cost half of what mine would.

The question therefore seems to be, What length should we go? Whether should we attempt to recover the whole of the waste heat, or be contented with taking the best of it? I think I have gone quite far enough; and in another furnace which I am at present constructing I have not gone so far; but having a large choice of materials ready at hand, and full liberty from my employer to use my own discretion in the matter, I was placed in a more favorable position for trying the experiment than most of those in charge of small gas works.

In the furnace which I am at present building, the producer is exactly the same as in the first one, but the flues are different. The waste heat flues are three in number. The two outside ones are 18 inches deep and 9 inches wide, and the middle one is 18 inches deep and 12 inches wide. The heat, after passing over the retorts, descends at the back of the oven into the two outside flues, comes forward to the back of the producer, and returns to the chimney in the center flue. Each of the two partitions between the center and outside flues consists of two 3 inch brick walls 6 inches apart, and tied together with baffle bricks, forming something like a hollow brick wall. These hollows are used as hot air flues. The air is admitted at the front, and passes along the side of the producer and along the bottom of the two outside flues in a 5 inch fire clay pipe. When at the back end of these flues, it is turned into the hollow walls, travels forward, and ascends into the bed of the oven, where it is conducted into each side of the producer by a channel 6 inches broad and 3 inches deep. The result of my year's experience has led me to modify the system thus far. I do not expect any better results from this than from my first one, but it is much less complicated, and will cost only about one-half. Such a furnace as this would be of considerable advantage in any small gas works, more even than in a medium sized works, where a regular night shift is kept on.—*Journal of Gas Lighting.*

BEET SUGAR AND ITS INDUSTRY.

By Prof. GUSTAV GEHRING, Chemist Missouri Agricultural Experiment Station, Columbia, Mo.

A HUNDRED years ago sugar was only a medicament. Although there are evidences of its high antiquity in India and China, it was nevertheless but vaguely known to the Greeks and Romans. Its introduction to Europe appears to have been one of the results of the crusades. For a long time, however, only the sweet juice was known, and the simple art of boiling it down and converting it into raw sugar is an invention of the fifteenth century. It was not until the middle of the following century that a Venetian discovered the art of refining sugar. If we are well informed, the first refinery was established in Dresden in 1597, and wherever introduced its progess was slow. To-day, sugar is one of the commonest necessaries of life and its industry has risen to a power which, in importance, is probably second to none.

All plants without exception contain sugar. Of all these only six plants, widely different in their aspects and properties, are at all used industrially for the purpose of its extraction; they are the sugar cane, the sugar beet, the sugar palm of the Indies, the maple tree, the sorghum, and the sugar corn. But even among these, only two plants have hitherto produced the almost entire amount of sugar consumed in the world.

They are the sugar cane and the sugar beet. The annual production of sugar in the entire world is for :

Cane sugar	5,038,000,000 lb.
Beet sugar.....	5,588,000,000 "
Total	10,626,000,000 lb.

If this enormous amount of sugar were made into a single loaf, it would form a cone whose base is 600 feet in diameter and whose altitude is 1,800 feet. To employ a comparison which would be more tangible to Parisians, and, no doubt, to those who have been there, it may be said that this quantity of sugar is equal to eight times the mass of the towers of Notre Dame. It has been proposed to estimate the relative civilization of communities by the consumption of certain commodities; so, for instance, Liebig says: "The quantity of soap consumed by a nation would be no inaccurate measure whereby to estimate its wealth and civilization." If these attempts of political economists are not altogether futile, the consumption of paper, I think, would be the truest measure of a nation's civilization. There we find that the United States come first with 550,000 tons, and Germany next with 240,000 tons. But it must be remembered that much depends on what paper is used for. Among the principal sugar-consuming nations of the world, England stands highest, with 72 lb. per head and per annum; next are the United States with 44 lb., then follow France with 24, and Germany with 15 lb.

Sugar is a general term applied by chemists to a number of neutral carbo-hydrates, possessing a more or less sweet taste, for the most part crystallizable and produced by the vital processes going on in certain plants and animals. The carbo-hydrates may be divided into three classes: sucroses, glucoses, and amyloses. We call them carbo-hydrates inasmuch as they contain hydrogen and oxygen in the proportion to form water, united with carbon. According to Liebig, the whole of the carbon in plants is obtained from the atmosphere. This was only an assertion, but the complete experimental proof required was furnished by Lawes and Gilbert in an experiment which lasted 44 years before a definite reply could be given. That the amount of carbon in sugar is great may be seen by decomposing it with concentrated sulphuric acid. Heat alone, however, can convert it into a porous, brilliant mass of carbon. It is easily combustible, especially with substances rich in oxygen. Sugar mixed with potassium chlorate can be ignited by a drop of sulphuric acid. At a temperature of 160° it melts to a colorless liquid, which on cooling solidifies to a transparent mass, called barley sugar. When heated more strongly, water is given off and caramel, a dark colored substance, is left behind. Being soluble in one-third of its weight of cold, it is much more so in hot, water. Alkaline solutions of the oxide of copper are not reduced by it, although it precipitates readily the noble metals. Cane sugar is not capable of undergoing directly fermentation, but in presence of yeast it takes up one molecule of water and is converted into dextrose and levulose: $C_{12}H_{22}O_{11} + H_2O = C_6H_{12}O_6 + C_6H_{12}O_6$. According to the equation of Lavoisier, sugar is equal to alcohol and carbonic acid, $C_6H_{12}O_6 = 2C_2H_6O + 2CO_2$. Pasteur, however, has shown that also 1½ per cent. of glycerin and ½ per cent. of succinic acid are formed. Chemically speaking, sugar is really an alcohol of an octad radical, and this is proved by the circumstance that an acetate of the form $C_{12}H_{14}O_3(C_2H_3O_2)_8$ can be obtained. When acted on in the cold by a mixture of nitric and sulpuric acids, a nitro-compound $C_{12}H_{14}(NO_2)_4O_{11}$ is formed which is liable to explode on percussion. Other alcohols are analogous in this respect; for instance, mannite, $C_6H_8(OH)_6$, a sugar-like substance, forms with nitric acid an ether, $C_6H_8(NO_2)_6O_6$, called nitro-mannite, which is one of the most wonderful substances known in chemistry. As an explosive it is more powerful than nitro-glycerin. Sugar is also remarkable for its high antiseptic properties, and is therefore used in the preservation of fruits and even meat. Finally, as a nutrient it is of great value, not because it can form blood and flesh directly, but because it is able to undergo in our bodies with the oxygen inhaled by respiration a slow but real combustion, thus producing heat, which, as has been recently shown by experiments, is directly convertible into force. Therefore, if it be added in the proper proportion to our aliments, it is really a source of muscular strength.

Until 1747, sugar was supposed to be the product of the sugar cane only. Marggraf, a German chemist, demonstrated that it existed as a natural product in many plants and especially in beet root. The manufacture of pure sugar from such material was, however, connected with great mechanical difficulties and did not succeed until the beginning of this century. So enormous has been the development of this industry during the last ten years that Europe now covers more than her own supply, and, as we have already seen, more than one-half of the world's entire production of sugar is due to this source. Marggraf, in his remarkable experiment, began by cutting beets into round, thin slices. After desiccation, he treated them with boiling alcohol and obtained thus in a crystallizer crystals of pure sugar. In 1787, Achard employed a process which was really the antipode of the one used in our days. He commenced by converting beet roots into fine pulp, and employed, instead of milk of lime, a small quantity of sulphuric acid, carefully calculated for the bases present. Sugar thus obtained is of fine taste and superior odor. Still, the product did not pay the cost, for only 2 or 3 per cent. of sugar were realized. During the Continental *blocus*, the price rose to a dollar a pound, and even after the fall of Napoleon, protective duties and improved methods of extraction soon gave France, for a long time, the monopoly of this important manufacture. Although the second empire did much to retard progress, France remained, nevertheless, at the head of this industry up to 1875, though she is now only third in rank. The increase in the production of beet sugar in France up to 1875 is shown in the following table :

In 1840 the production was			23,000 tons.
" 1845	"	"	36,000 "
" 1850	"	"	50,000 "
" 1855	"	"	92,000 "
" 1860	"	"	126,000 "
" 1865	"	"	149,000 "
" 1870	"	"	280,000 "
" 1875	"	"	451,000 "

Not many years ago, when France, in this respect, was nearly in the zenith of her prosperity, Germany sent two eminent scientists, Dr. Kraus and Dr. Schubert, for the purpose of studying completely the French process of manufacturing beet sugar. From that time on, as statistics prove, an important change took place.

Production of beet sugar in—

	France.	Germany.	Austria.
1874–1875..	451,000 tons.	251,000 tons.	222,000 tons.
1884–1885..	406,000 "	1,115,000 "	557,000 "

Beginning in 1875, when the annual production of sugar in Germany was but one-half of that in France, we see that in a single decade Germany attained the gigantic proportion of almost three times the production of France, whereas in the latter country there is a standstill. The commercial as well as the literary and artistic greatness of a nation, as may be perceived from history, is intimately linked with her political prosperity. France, the mother country of many arts and sciences of modern times, has, up to recent years, been a model of originality.

With rare sagacity and with a wonderful genius for generalization, she has, in countless instances, resolutely solved the difficult problems of newly created industries. The world, in reaping the fruits of her ardent labor, has often failed in her due recognition. The principal beet-sugar-producing countries in order of their importance are now: Germany, Austria, France, Russia, Belgium, and Holland.

France, who held once the monopoly in an industry that is so important to her, if not the most important of all, is now contemplating with heartrending despondency the causes of her inferiority. Considering that all the other nations cited are great exportative powers, the future of France, in this respect, must be viewed with apprehension, and it will be interesting for us to study the causes which in a few years have been operating this portentous change.

Can it be that the French process of manufacturing beet sugar is inferior to those used elsewhere? This is by no means the case. There are nowhere better nor more perfect methods of extraction than those actually employed in France. In this respect, she served as a model and has been largely imitated by other nations. Is it then that the area devoted to the culture of sugar beets is so much greater in the one country than in the other? Speaking strictly of the number of acres devoted to this purpose in Germany, it is but a trifle higher, and in comparison with the extraordinary results obtained, astonishingly low. It would seem, then, that higher returns per acre alone can account for the difference. But there we find just the contrary. Although the area of cultivation in Germany is a little larger, the returns per acre are smaller. Such conditions appear altogether paradoxical, and stimulate for research upon totally new and unexpected grounds. If it is neither the method of extraction, nor the area, nor the quantitative returns which can unveil this enigma, there remains but, as a kind of last resort, the quality of sugar beets. It is in this circumstance that the mystery finds its full explanation. In France, the richness of sugar for beets is only from 10 to 11 per cent., whereas in Germany it is from 13 to 15, and even as high as 18 per cent. The following tabulated data give succinctly a clear picture of the true cause of the French inferiority :

Number of hectares sown.

	1884.	1885.
France.....	226,000	238,000
Germany.....	254,000	292,000

	Average yield of beet roots per hectare.	*Average richness of sugar in beets.*
France.....	33,000 kil.	10 to 11 per cent.
Germany.....	32,000 "	13 to 15 "

This deplorable state of affairs in France has been brought on partly by faulty legislative enactments, but above all by a fundamental misapprehension of the requisites indispensable for a maximum yield of sugar. To realize the desideratum was no longer the task of the chemist nor of the manufacturer, but exclusively of the agriculturist. Numerous agricultural stations in Germany made it their object to study all the varitions of sugar beets, and proposed to farmers for cultivation those which yield the greatest percentage of sugar. They not only furnished to cultivators the proper seeds, but they pointed out all the essentials to be observed in this important culture, such as the kind of soil apt to produce beets richest in sugar, the manner of tilling the plants, the rotation of crops to be observed, the kind and quantity of manures to be employed, and the various artificial fertilizers, concerning the value of which our ideas of to-day enable us to speak with almost mathematical precision. So, for instance, he was cautioned against using manures or fertilizers which are too rich in ammonia and in nitrates. Such fertilizers tend to increase greatly the amount of salts in sugar beets. The quantity of beets varies according to the spacing. If the plants are 20 cm. apart, the returns per hectare are, on an average, 57,800 kil.; for 30 cm., 52,400 kil., and for 40 cm., 48,000 kil. In order to encourage the farmer to observe, rigorously, those empirical conditions, the manufacturers proposed to pay for beets a quotum which depended solely on the amount of sugar they contained. In France, the farmer was simply paid by the hundredweight, and was therefore naturally interested in obtaining the beets as large as possible, which, however, unfortunately for the manufacturer, are invariably poor in sugar. It is almost self-evident that the manufacturer and the farmer in this respect are mutually dependent, that is to say, that the system which is the most remunerative to the former must also be so to the latter.

Sugar beets contain only one kind of sugar. Already in 1838, Mr. Peligot announced the fact that sugar beets contain only saccharose. If thin slices of beet roots are boiled with water, the liquid thus obtained is not reduced with Fehling's solution unless previously inverted by a mineral acid. The amount of glucose in beet sugar is imperceptible, but it is quite notable in cane sugar, and sometimes as high as 11 per cent. Solutions of beet sugar are always slightly alkaline in their reaction, but those of cane sugar, on the contrary, are always acid.

The nitrogenous substances in sugar beets are of two kinds. First, a non-crystallizable, soluble substance, which is found in the residual matter in the form of methylamine. Its presence is shown by adding a concentrated boiling solution of potassium hydrate to the residue, when ammonia is disengaged. Second, non-crystallizable and insoluble substances, such as albumen and legumin, which are precipitated from the clear and filtered juice of the beets by concentrated calcium hydrate. In addition to these there exists still non-nitrogenous substances of a ternary nature, unknown to us, which are probably in a close relation to sugar. If the solid residual cake be digested with water containing one-tenth of its volume of hydrochloric acid, there is formed gelatin, a sort of jelly, known under the name of pectin. The cement in the plant is nothing else but the transformation of the pectose. If the cake or residual matter of the sugar beet be treated with a solution of Schweitzer, the cellulose is dissolved and can be precipitated by hydrochloric acid. By repeating this process several times, the cellulose can be obtained in white and beautiful flakes almost chemically pure.

Professor Girard has lately published his interesting investigations on the relative changes which are going on in the three principal parts of the beet-plant during the time of their complete development. He has thereby greatly elucidated the phenomena of the formation of sugar in the laboratory of the plant. The tabulated results given below are taken from a course of lectures delivered during last winter by that eminent scientist at the Conservatory in Paris. We see there that the vegetation of the beet extends over a period of five months, and that the stock alone weighs usually not over 700 or 800 gr. The relative weights of the three principal parts of the plant taken between June 17 and October 1, at intervals of nearly a month, with the exception of September, are the following :

	June 17.	July 15.	Aug. 24.	Oct. 1.
Radicals....	3·75	11·00	17·00	24·00
Stock.....	11·90	173·00	520 00	965·00
Leaves.....	63·00	402·00	442·00	537·00
	78·65	586·00	980·00	1,526·00

If these results be expressed in percentage, as shown in the accompanying table, certain deductions can be made :

	June 17.	July 15.	Aug. 24.	Oct. 1.
Radicals...	4·80	2·00	1·79	1 50
Stock. . ..	15·10	29 50	53·01	63·30
Leaves....	80·10	68·50	45 20	35·20
	100·00	100·00	100·00	100·00

The radicals, at first not unimportant, have a tendency to disappear. In the youthful life of the plant much of the nutriment is derived from the soil. But the leaves are more important still. They are the seat of the greatest activity. They are the real laboratory in which the sugar is manufactured by the action of the sun. Sunlight has the power in the presence of chlorophyl to decompose in the leaves the carbonic acid of the atmosphere. The carbon is assimilated by the plant, while the oxygen is set free. It is now well established that sugar forms during the daytime by the action of the sun in the leaves and stems of the plant, and migrates regularly during the night into the stock, so that in the morning the leaves are always poor in sugar, thus contributing powerfully to the accumulation of material in the stock. The leaves, too, diminish to less than one-half their original weight, while the stock alone, long before the period of maturity, has gained complete mastery. The composition of the stock during the various periods of its rapid development is, according to the results of Professor Girard, as follows :

	June 17.	July 15.	Aug. 24.	Oct. 1.
Water.....	85·81	85·11	82·24	82 40
Sucrose.....	4·49	8·98	11·30	12·19
Divers organic substances....	8·40	4·78	5·51	4·42
Mineral matter..	1·30	1·13	0·95	0·99
	100·00	100·00	100·00	100 00

The amount of water, we notice, remains nearly constant during its entire growth, and the same is true of the extremely small quantities of mineral matters. Many of the organic substances are changed into sugar, which constantly increases in weight. Hence, it would seem that the sole object of the sugar beet is to store up sugar, not so much for the purpose of gratifying our palate, as is supposed by some egoistic utilitarians who see in every object of nature the instrument that serves their worldly interests, but rather for its own use. Indeed, a sugar beet is nothing else but a sponge or vessel full of sugar water. So small, however, is the amount of the material which constitutes the vessel, that it would well nigh be impossible for us to construct one equally as light and substantial.

In addition to the great amelioration of the industry already referred to with respect to the proper selection of the plant, there is still to be mentioned the improvement made in the extraction of the juice. According to the old process, which, however, is still in use in some places, beet roots are rasped to a fine pulp and then subjected to pressure. The juice thus obtained contains nearly all of the salts in solution, and is very black. Totally different from this is the new process. It is a process of diffusion. Soon after its introduction in Austria, in 1864, it spread over Germany and Russia, but was not adopted in France until 1876, though the idea originated there as early as 1820. Unfortunately for the inventor, he thought that boiling water was absolutely necessary, and under those circumstances, of course, the process could never become practical. Now simply cold water is used. The beet roots are cut with very sharp instruments into round thin slices so as to disintegrate them as little as possible. They are then subjected to a methodical maceration, and if they are well and clean cut, they yield a juice which is yellow and clear. By this osmotic phenomenon the juice obtained is remarkably free from salts, and contains neither albumen nor other organic substances. The process of purification is, therefore, much less complicated, and also the returns in sugar are higher by one per cent.

And now we have seen in a rapid review the rise of a new industry. At first its slow and laborious growth, and then suddenly in our times and even under our eyes we have seen it develop to a power which challenges our admiration. Are there not some lessons for us in that patient labor which resulted in the embodiment of facts which constitute a triumph in

modern science? So far, in the United States, the sugar cane occupied the principal place, but in 1857 a plant derived from Chinese seed, the sorghum, was introduced. Of the latter many varieties are now in cultivation, which naturally differ in their qualities as sugar producers.

It is remarkable that in this respect the problem is identical with the one that has been already so satisfactorily solved in Europe, namely, the problem of the sugar beets.

Professor H. W. Wiley, of the United States Department of Agriculture, clearly stated last summer before the Association for the Advancement of Science that the question of obtaining the maximum amount of sugar from this plant is neither a chemical nor an industrial one, for almost any factory nowadays is able to extract nearly all the sugar obtainable from a given juice, but that the success depends altogether on the selection of the plants, for there is an enormous difference in the amount of sugar they contain. The beet sugar industry in this country has been established long ago, but is quite diminutive, and has met with little success. No doubt, a new impulse will be given to this industry, for not many weeks ago the most prominent American sugar refiner, a Californian, arrived from Germany, where he had been investigating the manufacture of beet sugar, and brought with him receipts for many thousand dollars' worth of machinery.

Whatever may be the results of this enterprise, it will always be gratifying to us to know at least the means whereby, if necessary, we can render ourselves independent in our supply of sugar, not only from semi-tropical regions, but, above all, from foreign countries. PROF. GUSTAV GEHRING, Chemist.

Missouri Agricultural Experiment Station,
Columbia, Mo.

RESTORING FADED PHOTO. PRINTS.

H. LANDAURER, of Teschen, received a medal from the Photographic Society of Vienna for a process of reproducing and restoring albumen prints that have faded. His baths are:

No. 1.

Tungstate of soda	100 grams	or 3½	ounces.
Distilled water	5,000 c. centim.	" 175	"

No. 2.

Carbonate of lime (C. P.)	4 grams	or 62	grains.
Chloride of lime	1 gram	or 15½	"
Chloride of gold and soda	4 grams	or 62	"
Distilled water	400 c. centim.	or 14	ounces.

Solution No. 2 is made in a yellow glass bottle, well stoppered, and allowed to stand for twenty-four hours before use. It is then filtered into another bottle of yellow glass and, to preserve it, well corked.

To use it say for a sheet of albumenized paper, take 150 centimeters (5¼ ounces) of No. 1 to from four to eight centimeters (1 to 2 drachms) of No. 2. The prints, well washed, are placed one at a time in this bath. The strengthening must not be too rapid, ten minutes being sufficient in summer, and the bath must not contain an excess of chloride of gold. Properly used, a beautiful clear purple color is obtained. To fix the prints take 150 centimeters (5¼ ounces) of solution No. 1 to fifteen centimeters (4 drachms) of hyposulphite of soda. The strengthened prints are well washed, placed in this bath one at a time, and soaked until the yellow color is entirely gone; which requires in some cases from three to five hours, when they are thoroughly washed.

NOVEL MAGNESIUM LAMP AND REFLECTOR.

HERR FR. DIEL, of Cologne, has constructed a double reflector for magnesium lamps, which has the advantage that it allows an intense illumination of large surfaces at very short distances. It is well known to the photographic operator that, while he has generally to do with the parallel rays of daylight, the rays emanating from a magnesium lamp are distributed fan shaped on the subject. It was, therefore, necessary, if large surfaces were to be illuminated, to place the lamp very far off the subject, which, however, was not at all convenient, and sometimes—as, for instance, in galleries—even impossible.

The new double reflector of M. Diel will, therefore, be welcome to many operators. I give here three sketches of the arrangement, Fig. 1 being the front view, Fig. 2 the profile, and Fig. 3 the lamp itself, side view. It consists of a brass star, D (Fig. 2), into the radial sockets of which (*d*) the screen sticks, B, are inserted. To the ends of these sticks hooks are attached, in which a white screen, *c* (of linen, for instance), is hung pyramidally by rings. Inside this screen is inserted the silvered reflector, E (Fig. 1), with the magnesium lamp, F. In this lamp are put, between little metal plates, *g* (Fig. 3), by aid of a clamp screw, several

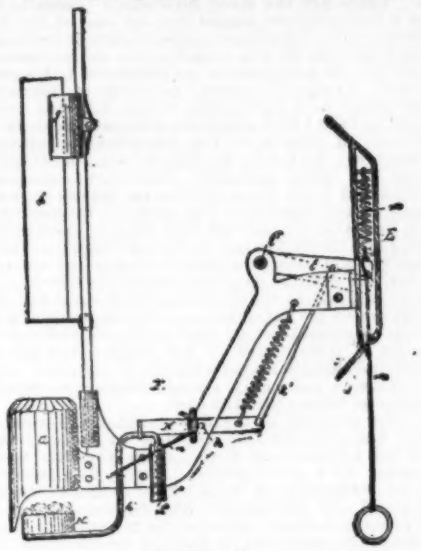


FIG. 3.

strips of magnesium band, *h*, which are held over the burner, G. Below the latter a cup, H, is fixed for a spirit flame, which, by aid of a spring, *n*, can be pushed in a lateral position. To take a photograph, at first two, three, or four strips of magnesium band are fixed in the adjustable clamps, *g*, then the laterally displaced cup, H, is ignited, and, after focusing, the spring of the arm, K, released by drawing the cord, *m*, hanging down from the back of the reflector, E. This causes the cup, H, shooting under the burner, G, whereby the magnesium band is ignited. Two or three strips of magnesium band of five inches length each will burn about nine seconds. In a similar manner also magnesium powder can be burnt with this arrangement. The whole double reflector is fixed as a tripod stand, A, and can be adjusted in any angle, and upward as well as downward and horizontally.—*H. E. Gunther, in Photo. News.*

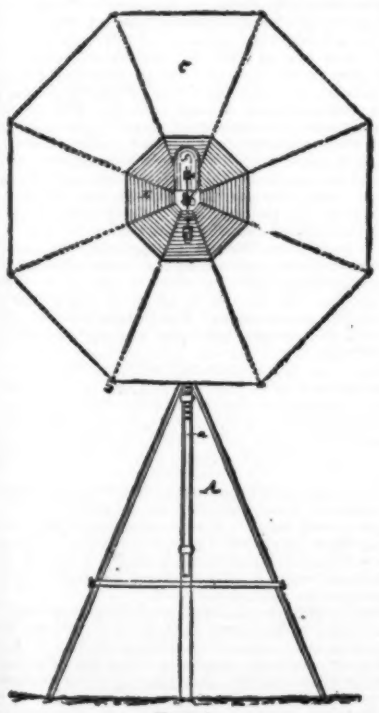


FIG. 1.

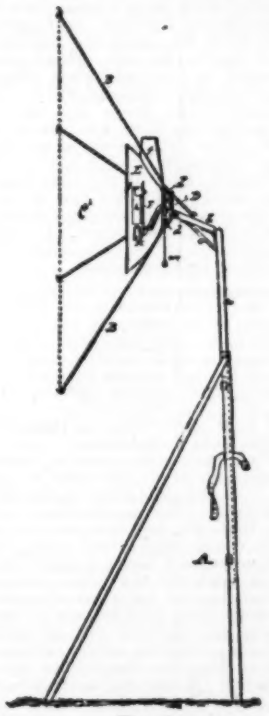


FIG. 2.

ELECTRO-CHEMICAL RADIOPHONE.

CHAPERON and Mercadier employ a galvanic cell composed of one plate of silver coated by electrolysis of sulphide of sodium with a very thin layer of sulphide of silver, and another plate of silver. Both plates are placed in a liquid conductor, water acidulated with sulphuric acid, for instance. The cell possesses a very feeble electromotive force. It polarizes very rapidly and gives rise to variable instantaneous currents under the action of very feeble light. By means of a radiophonic wheel, an intermittent beam of light corresponding to a tone of 1,000 vibrations was allowed to fall on the cell, and the note was heard in a telephone inclosed in the circuit. This note was due to an electro-chemical effect, the duration of which was less than $\frac{1}{1000}$ of a second.—*Comptes Rendus; Amer. Jour., June 4, 1888.*

THE PRACTICAL APPLICATIONS OF ELECTRICITY.*

By Mr. WILLIAM HENRY PREECE, F.R.S., M. Inst. C. E.

"CANST thou send lightnings, that they may go, and say unto thee, Here we are?" were pregnant words addressed to Job unknown centuries ago. They express the first recorded idea in history of the potentiality of electricity to minister to the wants of mankind. From Job to Franklin is a long swing in the pendulum of time. It was not until that American philosopher brought down atmospheric electricity by his kite string in 1747, and showed that we could lead it where we willed, that we were able to answer the question addressed to the ancient patriarch. Nearly another century elapsed before this mysterious power of nature was fairly conquered. It has been during this generation, and during the life of the British Association, that electricity has been usefully employed; and it is because I have taken a subordinate position in inaugurating nearly all of its practical applications, that I venture to make the developments of them the text of my address to this section. People are singularly callous in matters affecting their own personal safety; they will not believe in mysteries, and they ridicule or condemn that which they do not understand. The Church itself set its face against Franklin's "impious" theories, and he was laughed to scorn by Europe's scientific sons; and even now, though commissions composed of the ablest men of the land have sat and reported on Franklin's work in England, France, and nearly every civilized nation, the public generally remains not only ignorant of the use of lightning conductors, but absolutely indifferent to their erection, and, if erected, certainly careless of their proper maintenance. I found in a church not very far from here the conductor leaded into a tombstone, and in a neighboring cathedral the conductor only a few inches in the ground, so that I could draw it out with my hand. Although I called the attention of the proper authorities to the absolute danger of the state of affairs, they remained in the same condition for years.

Wren's beautiful steeple in Fleet Street, St. Bride's, was well nigh destroyed by lightning in 1764. A lightning rod was fixed, but so imperfectly that it was again struck. In July last year, it was damaged because the conductor had been neglected, and had lost its efficiency. As long as points remain points, as long as conductors remain conductors, as long as the rods make proper connection with the earth, lightning protectors will protect; but if points are allowed to be fused, or to corrode away, as long as bad joints or faulty connections are allowed to remain, as long as bad earths or no earths exist, so long will protectors cease to protect, and they will become absolute sources of danger. Lightning conductors, if properly erected, duly maintained, and periodically inspected, are an absolute source of safety; but if erected by the village blacksmith, maintained by the economical churchwarden, and never inspected at all, a loud report will some day be heard, and the beautiful steeple will convert the churchyard into a new geological formation. We have not yet acquired that mental confidence in the accuracy of the laws that guide our procedure in protecting buildings from the effects of atmospheric electric discharges which characterizes most of the practical applications of electricity. Some of our cherished principles have only very recently received a rough shaking from the lips of Professor Oliver Lodge, F.R.S., who, however, has supported his brilliant experiments by rather fanciful speculation, and whose revolutionary conclusions are scarcely the logical deduction from his novel premises. The whole subject is going to be thoroughly discussed at this meeting.

We are now obtaining much valuable information about the nature of lightning from photography. We learn that it does not, as a rule, take that zigzag course conventionally used to represent a flash on canvas. Its course is much more erratic and sinuous, its construction more complicated, and pictures have been obtained of dark flashes whose *raison d'etre* has not yet been satisfactorily accounted for. The network of telegraph wires all over the country is peculiarly subject to the effects of atmospheric electricity, but we have completely mastered the vagaries of lightning discharges in our apparatus and cables. Accidents are now very few and far between.

The art of transmitting intelligence to a distance beyond the reach of the ear and eye, by the instantaneous effects of electricity, had been a dream of a philosopher for nearly a century, when, in 1837, it was rendered a practical success by the commercial and far-sighted energy of Cooke and the scientific knowledge and inventive genius of Wheatstone. The metallic arc of Galvani, 1790, and the developments of Volta, 1796, had been so far improved that currents could be generated of any strength. The law of Ohm, 1828, had shown how they could be transmitted to any distance; the deflection of the magnetic needle by Oersted in 1819, and the formation of an electro-magnet by Ampere and Sturgeon, and the attraction of its armature, had indicated how those currents could be rendered visible as well as audible. Cooke and Wheatstone, in 1837, utilized the deflection of the needle to the right and the left to form an alphabet. Morse used the attraction of the armature of an electro-magnet to raise a metal style to impress or emboss moving paper with visible dots and dashes. Steinheil imprinted dots in ink on the different sides of a line on paper, and also struck two bells of different sound to affect the ear. Breguet reproduced in miniature the actual movements of the semaphore then so much in use in France; while others rendered practical the favorite idea of moving an indicator around a dial, on which the alphabet and the numerals were printed, and causing it to dwell against the symbol to be read—the A B C instrument of Wheatstone in England and of Siemens in Germany. Wheatstone conceived the notion of printing the actual letters of the alphabet in bold Roman type on paper—a plan which was made a perfect success by Hughes in 1854. At the present moment the needle system of Cooke and Wheatstone, as well as the A B C dial telegraph, are very largely used in England on our railways and in our smaller post offices. The Morse recorder and the Hughes type printer are universally used on the Continent, while in America the dot and dash alphabet of Morse is im-

* The British Association, 1888. Presidential address, Section G.

pressed on the consciousness through the ear by the sound of the moving armature striking against the stops that limit its motion. In our larger and busier offices the Morse sounder and the Bell system, as perfected by Bright, are very largely used, while the press of this country is supplied with news which is recorded on paper by ink dots and dashes at a speed that is almost fabulous. Sir William Thomson's mirror—the most delicate form of the needle system—where the vibratory motions of an imponderable ray of light convey words to the reader, and his recorder, where the wavy motion of a line of ink spurted on paper by the frictionless repulsion of electricity performs the same function, are exclusively employed on our long submarine cables.

Bakewell in 1848 showed how it was possible to reproduce facsimiles of handwriting and of drawing at a distance, and in 1879 E. A. Cowper reproduced one's own handwriting, the moving pen at one station so controlling the currents flowing on the line wire that they caused a similar pen to make similar motions at the other distant station. Neither of these plans, the former beautifully developed by Caselli and D'Arlincourt, and the latter improved by Robertson and Elisha Gray, have yet reached the practical stage. The perfection of telegraphy has been attained by that chief marvel of this electrical age—tha speaking telephone of Graham Bell. The reproduction of the human voice at a distance, restricted only by geographical limits, seems to have reached the confines of human ingenuity; and though wild enthusiasts have dreamt of reproducing objects abroad visible to the naked eye at home, no one at the present moment can say that such a thing is possible, while, in face of the wonders that have been done, no one dare say that it is impossible. The commercial business of telegraphy, when our thoughts and wishes, orders and wants, could be transmitted for money, was inaugurated in this country by the establishment of the Electric Telegraph Company in 1846, and, until 1870, it remained in the hands of private enterprise, when it was purchased by the government, and placed under the sole control of the postmaster-general. It has been the fashion to decry the terms of purchase of the various undertakings then at work by those who have not understood the question, and by those who, being politically opposed to the government in power at the time, saw all their acts, not only through a glass darkly, but through a reversing lens. A business producing £550,000 per annum was bought at twenty years' purchase, and that business has now increased to £2,000,000 per annum. 6,000,000 messages have increased to 52,000,000. Every post office has been made a telegraph office, every village of any size has its wire; messages which used to cost 12s. 6d. are now sent for 6d.; a tariff which was vexatious from its unfair variation is now uniform over the United Kingdom, and no one can justly complain of error or delay in the transmission of their messages. Silly complaints are sometimes inserted in the press of errors which the most elementary knowledge of the Morse alphabet would detect, and little credit is given to the fact that the most perfect telegraph is subject to strange disturbances from terrestrial and atmospheric causes which admit sources of error beyond the control of the telegraphist. A flash of lightning in America may cause an extra dot in Europe, and *man* may become *war*. An earthquake in Japan may send a dash through France, and *life* would become *wife*. A wild goose flying against a telegraph wire might drive it into momentary contact with another wire, and *sight* might become *night*. Every one should know his Morse alphabet, and people should learn how to write. Nine-tenths of the errors made are due to the execrable caligraphy of the present day. As a matter of fact, in ninety-nine cases out of a hundred, the telegraphist delivers to the editor of a newspaper "copy" far more accurate than the first proof of his own leader submitted by the printer. The quantity of news transmitted is enormous. An average of 1,538,270 words are delivered per day. The recent convention in Chicago, when the Republican party of the United States nominated their candidate for the presidentship, created so much business that every American paper has chronicled this big thing as unique. Five hundred thousand words were sent on one night; but we in England, when Mr. Gladstone introduced his celebrated home rule bill on April 8, 1886, sent from the central telegraph office in London 1,500,000 words.

The growth of business has led to vast improvement in the carrying capacity of the wires. Cooke and Wheatstone required five wires for their first needle instrument to work at the rate of four words per minute. One wire can now convey six messages at ten times the speed. The first Morse apparatus could work at about five words a minute; we now transmit news at the rate of 600 words a minute. In 1875 it was thought wonderful to transmit messages to Ireland at 80 words a minute. When I was recently in Belfast I timed messages coming at the rate of 461 words a minute. Duplex working—that is, two messages traveling on the same wire at the same time in opposite directions, the invention of Gintl, of Vienna—is now the normal mode of working; Edison's quadruplex is common; and the Delany system of multiplex working is gradually being introduced, by which six messages are sent indiscriminately in either direction. The telegraphic system of England has been brought to the highest pitch of perfection. We have neither neglected the inventions of other countries nor have we been chary of exercising inventive skill ourselves, and we have received our full meed of that reward which is always freely bestowed on a British government official—neglect and abuse. All parts of the civilized world are now united by submarine cables. The *Times* every morning has dispatches from every quarter of the globe, giving the news of the previous day. 110,000 miles of cable have been laid by British ships, and nearly £40,000,000 of British capital has been expended by private enterprise in completing this grand undertaking. A fleet of thirty-seven ships is maintained in various oceans to lay new cables and to repair breaks and faults as they occur—faults that arise, among other causes, from chafing on coral reefs, ships' anchors, the onslaught of insects, and earthquakes. The two cables connecting Australia and Java were recently simultaneously broken by an earthquake. The politician, unmindful of the works of the engineer, is apt to apply to the credit of his own proceedings the growing prosperity of the world. The engineer, however, feels that steam and electricity in his hands have done more to economize labor, to cheapen life, to increase wealth, to promote international friendship, to alleviate suffering, to ward off war, to encourage peace, than all the legislation and all the verbosity of the politician.

The railways of this country are entirely dependent for the conduct of their traffic on the telegraph, and the security of their passengers is mainly due to the working of the block system. A railway, say, between London and Bath, is broken up into certain short sections, and only one train is allowed on one section at one time. The presence, motion, and departure of trains is announced and controlled by electric signals, and the outdoor signals are governed by these electric signals. There are few more interesting places to visit than a well equipped signal box on one of our main railways. The signalman is able to survey the lines all around and about him by aid of his electric signals; he can talk by telegraph or by telephone to his neighbors and his station master; he learns of the motion of the trains he is marshaling by the different sounds of electric bells; he controls his outdoor signals by the deflection of needles, or the movement of miniature semaphores; he learns the true working of his distant signals by their electrical repetition; machinery governs and locks every motion he makes, so that he cannot make a mistake. The safety of railway traveling is indicated by the fact that while in the five years ending 1878 thirty-five people were killed annually from causes beyond their own control, in the five years ending 1887 the average has been reduced to sixteen. One person is killed in 35,000,000 journeys made by train. Wherever we are dependent on human agency we are subject to human error; and a serious accident very recently at Hampton Wick has shown how the most perfect machinery may be rendered valueless to protect life when perversity, thoughtlessness, or criminality enter as factors into the case.

At the meeting of the Association in Plymouth, in 1877, I was able, for the first time in this country, to show the telephone at work. Since then its use has advanced with giant strides. There are probably a million instruments at work now throughout the civilized world. Its development has been regularly chronicled at our meetings. As far as the receiving part of the apparatus is concerned, it remains precisely the same as that which I brought over from America in 1877; but the transmitter, ever since the discovery of the microphone by Hughes in 1878, has been entirely remodeled. Edison's carbon transmitter was a great step in advance; but the modern transmitters of Moseley, Berliner, D'Arsonval, De Jongh, leave little to be desired. The disturbances due to induction have been entirely eliminated, and the laws regulating the distance to which speech is possible are so well known that the specification of the circuit required to connect the Land's End with John o' Groat's by telephone is a simple question of calculation. A circuit has been erected between Paris and Marseilles, 600 miles apart, with two copper wires of 6½ gauge, weighing 540 lb. per mile, and conversation is easily maintained between those important cities at the cost of three francs for three minutes. One scarcely knows which fact is the more astounding—the distance at which the human voice can be reproduced, or the ridiculously simple apparatus that performs the reproduction. But more marvelous than either is the extreme sensitiveness of the instrument itself, for the energy contained in one heat unit (gramme water degree) would, according to Pellat, maintain a continuous sound for 10,000 years. The influence which electric currents exert on neighboring wires extends to enormous distances, and communication between trains and ships in motion, between armies inside and outside besieged cities, between islands and the mainland, has become possible without the aid of wires at all, by the induction which is exerted through space itself. On the Lehigh Valley Railway, in the United States, such a system of telegraphing without wires is in actual daily use. The conduct of telephonic business in England is still in the hands of those who hold the patents, and who maintain a most rigid monopoly. These patents have only a short period to run, and when they expire we may expect to find that England will not occupy the very retired position she holds now as a telephone country. Stockholm has more subscribers than London; there are 15,000 subscribers in and about New York, while the number in London is only 4,851.

The production of light by any means implies the consumption of energy, and this can be measured in watts, or the rate at which this energy is consumed. A watt is $\frac{1}{746}$ part of a horse power. It is a very convenient and sensible unit of power, and will in time replace the meaningless horse power.

One candle light maintained by tallow		absorbs	124	watts.
"	" wax	"	94	"
"	" sperm	"	86	"
"	" mineral oil	"	80	"
"	" vegetable oil	"	57	"
"	" coal gas	"	68	"
"	" cannel gas	"	48	"
"	" electricity (glow)	"	55	"
"	" electricity (arc)	"	3	"

The relative heat generation of these illuminants may be estimated from these figures.

Electric lighting has become popular, not alone from the beauty of the light itself, but from its great hygienic qualities in maintaining the purity and coolness of the air we breathe. The electric light need not be more brilliant than gas, but it must be more healthy. It need not be cooler than a wax candle, but it must be brighter, steadier, and more pleasant to the eye. In fact, it can be rendered the most perfect artificial illuminant at our disposal, for it can illumine a room without being seen directly by the eye; it can be made absolutely steady and uniform without irritating the retina; it does not poison the air by carbonic acid and carbonic oxide, or dirty the decorations by depositing unconsumed carbon; it does not destroy books or articles of vertu and art by forming water which absorbs sulphur acids; and it does not unnecessarily heat the room. In our Central Savings Bank in London it has been found, after two years' experience of electric lighting, that the average amount of absences from illness has been diminished by about two days a year for each person on the staff. This is equivalent to a gain to the service of the time of about eight clerks in that department alone. Taking the cost at the "overtime" rate only, this would mean a saving in salaries of about £640 a year. The cost of the installation of the electric light was £3,349, and the annual cost of working £700 per annum, say a total annual cost of £1,084. The cost of the gas consumed for lighting purposes was about £700 a year, so that on the whole there was a direct saving of something like £366 a year to the government, besides the material advantage of the better work of the staff resulting from the improved atmospheric conditions under which their work is done.

Though the electric light was discovered by Davy in 1810, it was not until 1844 that it was introduced into our scientific laboratories by Foucault; it was not until 1878 that Jablochkoff and Brush showed how to light up our streets effectually and practically. It was not until 1881 that Edison and Swan showed how our homes could be illuminated softly and perfectly. Unpreparedness for such a revolution produced a perfect panic among gas proprietors. Inexperience in the use of powerful electric currents resulted in frequent failure and danger; speculation in financial bubbles transferred much gold from the pockets of the weak to the coffers of the unscrupulous; hasty legislation in 1882 restricted the operations of the cautious and the wise; and the prejudice arising from all these causes has, perhaps fortunately, delayed the general introduction of electricity. But now legislation has been improved, experience has been gained, confidence is restored, and in this beautiful town of Bath fifty streets are about to be lighted, and we see everywhere around and about us in our English homes the pure glow lamp replacing filthy gas and stinking oil. The economical distribution of the electric current over large areas is annually receiving a fresh impetus. The expensive systems defined in the act of Parliament of 1882 have entirely disappeared. Hopkinson in England and Edison in America showed how a third wire reduced the weight of copper needed by 66 per cent. Gaulard and Gibbs in 1882 showed how the conversion of alternate currents of high electromotive force to currents of low electromotive force by simple induction coils would enable a mere telegraph wire to convey sufficient electricity to light a distant neighborhood economically and efficiently. Lane Fox in 1879 showed how the same thing could be done by secondary batteries; and Planté, Faure, Sellon, and Parker have done much to prove how batteries can be made to solve the problem of storage; while King and Edmunds have shown how the distribution by secondary batteries can be done as economically as by secondary generators. The Grosvenor Gallery Company in London have proved the practicability of the secondary generator principle by nightly supplying 24,000 glow lamps scattered over a very wide area of London. The glow lamp of Edison, which in 1881 required 5 watts per candle, has been so far improved that it now consumes but 2¼ watts per candle. The dynamo, which in the same year weighed 50,000 lb., absorbed 150 horse power, and cost £4,000 for 1,000 lamps, now weighs 14,000 lb., absorbs 110 horse power, and costs £500 for the same production of external energy; in other words, its commercial output has been increased nearly six times, while its prime cost has been diminished eight times.

The steam engine has received equal attention. The economy of the electric light when steam is used depends almost entirely on the consumption of coal. With slow-speed low-pressure engines one kilowatt—1,000 watts, 1⅓ horse power—may consume 12 lb. of coal per hour; in high-speed high-pressure triple-expansion engines it need not consume more than 1 lb. of coal per hour. Willans and Robinson have actually delivered from a dynamo one kilowatt by the consumption of 2 lb. of coal per hour, or by the condensation of 20 lb. of steam. There is a great tendency to use small economical direct-acting engines in place of large, expensive engines, which waste power in countershafting and belts. Between the energy developed in the furnace in the form of heat and that distributed in our rooms in the form of light, there have been too many points of waste in the intermediate operations. These have now been eliminated or reduced. Electricity can now be produced by steam at 3d. per kilowatt per hour. The kilowatt hour is the Board of Trade unit as defined by the act of 1882, for which the consumer of electric energy has to pay. Its production by gas engines costs 6d. per kilowatt hour, while by primary batteries it costs 3s. per kilowatt hour. The Grosvenor Gallery Company supply currents at 7¼d. per kilowatt hour; a 20-candle power lamp consuming 3 watts per candle, and burning 1,200 hours per annum, expends 82,000 watt hours or 82 kilowatt hours, and it costs, at 7¼d. per unit, 50s. per annum. If the electricity be produced on the premises, as is the case in the post office, in the House of Commons, and in many large places, it would cost 20s. 6d. per annum. I have found from a general average under the same circumstances, and for the same light, in the General Post Office in London, that an electric glow lamp costs 22s. and a gas lamp 18s. per annum. The actual cost of the production of one candle light per annum of 1,000 hours is as follows:

	s.	d.
Sperm candles	8	6
Gas (London)	1	3
Oil (petroleum)	0	8
Electricity, glow	0	9
" arc	0	1½

The greatest development of the electric light has taken place on board ship. Our Admiralty have been foremost in this work. All our war ships are gradually receiving their equipment. Our ocean-going passenger ships are also now so illumined, and perhaps it is here that the comfort, security, and true blessedness of the electric light is experienced.

Railway trains are also being rapidly fitted up. The express trains to Brighton have for a long time been so lighted, and now several Northern railways, notably the Midland, are following suit. Our rocky coasts and prominent landfalls are also having their lighthouses fitted with brilliant arc lamps, the last being St. Katherine's Point on the Isle of Wight, where 60,000 candles throw their bright beams over the English Channel, causing many an anxious mariner to proceed on his way rejoicing.

Fontaine showed in Vienna, in 1873, that a dynamo was reversible—that is, if rotated by the energy of a moving machine, it would produce electric currents; or, if rotated by electric currents, it would move machinery. An electric current is one form of energy. If we have at one place the energy of falling water, we can, by means of a turbine and a dynamo, convert a

certain portion of the energy of this falling water into an electric current. We transmit this current through proper conductors to any other place we like, and we can again, by means of a motor, convert the energy of the current into mechanical energy to do work by moving machinery, drawing tramcars, or in any other way. We can in this way transmit and utilize 50 per cent. of the energy of the falling water wherever we like. The waste forces of nature are thus within our reach. The waterfalls of Wales may be utilized in London; the torrents of the Highlands may work the tramways of Edinburgh; the wasted horse power of Niagara may light up New York. The falls of Bushmills actually do work the tramway from Portrush to the Giant's Causeway, and those of Bessbrook the line from Newry to Bessbrook.

The practicability of the transmission of energy by currents is assured, and the economy of doing this is a mere matter of calculation. It is a question of the relative cost of the transmission of fuel in bulk, or of the transmission of energy by wire. Coal can be delivered in London for 12*s.* per ton. The mere cost of the upkeep of a wire between Wales and London to deliver the same amount of energy would exceed this sum tenfold. For long distances the transmission of energy is at present out of the question. There can be no doubt, however, that for many purposes within limited areas the transmission of energy by electricity would be very economical and effective. Pumps are worked in the mines of the Forest of Dean, cranes are moved in the works of Easton and Anderson at Erith, lifts are raised in banks in London; water is pumped up from wells to cisterns in the house of Sir Francis Truscott, near East Grinstead; ventilation is effected and temperature lowered in collieries; goods, minerals, and fuel can be transmitted by telpherage. The transmission of power by electricity is thus within the range of practice. It can be distributed during the day by the same mains which supply currents for light by night. Small industries, such as printing, watchmaking, tailoring, bootmaking, can be cheaply supplied with power. It is thus brought into direct competition with the distribution of power by steam as in America, or by air pressure as in Paris, or by high pressure water as in London; and the relative advantages and economies of each system are simple questions of calculation. When that evil day arrives that our supply of natural fuel ceases, then we may look to electricity to bring to our aid the waste energies of nature—the heat of the sun, the tidal wave of the ocean, the flowing river, the roaring falls, and the raging storm.

There is a mode of transport which is likely to create a revolution in the method of working tramways. A tramcar carries a set of accumulators which supplies a current to work a motor geared to a pair of wheels of the car. The weight, price, day's work, and life of the accumulator is curiously the same as the weight, price, day's work, and life of horseflesh; but the cost of maintenance, the liability to accident, and the chances of failure are much less. Although very great improvements in batteries have been made, and they are now really practical things, sufficient experience in tramcar working has not yet been obtained to say that we have reached the proper accumulator. Nor have we yet acquired the best motor and mode of gearing; but very active experiments are being carried out in various countries, and nothing can prevent their ultimate success.

The property which the electric current possesses, of doing work upon the chemical constitution of bodies, so as to break up certain liquid compounds into their constituent parts, and marshal these disunited molecules in regular order, according to a definite law, upon the surfaces of metals in contact with the liquid where the current enters and exists, has led to immense industries in electro metallurgy and electro plating. The extent of this industry may be gathered from the fact that there are 172 electro platers in Sheffield and ninety-nine in Birmingham. The term electro metallurgy was originally applied to the electro deposition of a thin layer of one metal on another; but this is now known as electro plating. In 1839, Jacobi in St. Petersburg and Spencer in Liverpool laid the foundations of all we know of these interesting arts. Copper was deposited by them so as to obtain exact reproductions of coins, medals, and engraved plates. The first patents in this country and in France were taken out by Messrs. Elkington, of Birmingham, who still occupy the foremost position in the country. The fine metals, gold and silver, are deposited in thin layers on coarser metals, such as German silver, in immense quantities. Christofle, of Paris, deposits annually six tons of silver upon articles of use and of art, and if the surfaces so electroplated were spread out continuously, they would cover 140 acres. The whole of the copper plates used in Southampton for the production of our splendid ordnance survey maps are deposited by copper on matrices taken from the original engraved plates, which are thus never injured or worn, and are always ready for addition or correction, while the copies may be multiplied at pleasure and renewed at will. Nickel plating, by which the readily oxidizable metals like iron are coated with a thin layer of the more durable material, nickel, is becoming a great industry; the trappings of harness, the exposed parts of machinery, the fittings of cycles and carriages, and innumerable articles of daily use are being rendered not only more durable, but more beautiful. The electro deposition of iron, as devised by Jacobi and Klein, in the hands of Professor Roberts-Austen, F.R.S., is giving very interesting results. The dies for the coins which were struck at our mint on the occasion of the jubilee of the Queen were modeled in plaster, reproduced in intaglio by the electro deposition of copper, and on these hard, excellent iron in layers of nearly one-tenth of an inch was deposited.

The exact processes of measurement, which have led to such vast improvement in our telegraphic systems, have scarcely yet penetrated into this field of electrical industry, and little is known at present of the exact relations of current and electro-motive force with respect to surfaces of contact, rate of deposit, and resistance of liquids. Captain Sankey, R.E., of the Ordnance Survey Department, has done some useful work in this direction. The extraction of metals from their ores by deposition has received wide application in the case of copper. In 1871 Elkington proposed to precipitate copper electrolytically from the fused sulphide of copper and iron known to the copper smelter as "regulus." Thin copper plates were arranged to receive the deposited copper, while the foreign metals, including gold and silver, fell to the bottom of the solution, the process being specially applicable, it was supposed, to regulus containing small quantities of the precious metals. The electrical purification of copper from impure "blister copper" or "blade copper" has also made great progress, and special dynamos are now made which will, with an expenditure of 100 horse power, precipitate 18 tons of copper per week. The impure metal is made to form the anode in a bath of sulphate of copper, the metal being deposited in the pure form on a thin copper cathode. It was not very long ago considered very economical to absorb 0·85 horse power in depositing one pound of copper per hour, but now the same work can be done with 0·3 horse power. Mr. Parker, of Wolverhampton, has done good work in this direction, and his dynamos in Messrs. Bolton's works have revolutionized this process of purification. Both at Swansea and Widnes immense quantities of copper, in spite of the restrictive operations of the copper syndicate, are being produced by electro deposition. Copper steam pipes for boilers are now being built up of great firmness, fine texture, and considerable strength by Mr. Elmore, at Cockermouth, by electro deposition on a rotating mandrel in a tank of sulphate of copper. By this process one ton of copper requires only a little more than one ton of coal to raise the requisite steam to complete the operation.

It has been shown that the electrolytic separation of silver from gold by similar methods is perfectly practicable. The value of the material to be dealt with may be gathered from the fact, communicated to the gold and silver commission now sitting, that nearly 90,000,000 oz. of silver are annually produced, and the greater portion of this amount contains sufficient gold to render refining remunerative. Although the old acid process of "parting gold" and silver remains practically undisturbed, there seems no reason to doubt that in the future electricity will render us good service in this direction, as it has already in the purification of copper. There is not much actual progress to report in the extraction of gold from its ores by electrical agency. The conversion of gold into chloride of gold by the direct or indirect action of chlorine is employed on a very large scale in Grass Valley, California, and elsewhere. This fact has led to well directed efforts to obtain, by electrolytic action, chlorine which should attack finely divided gold suspended—with the crushed ore—in the solution from which the chlorine was generated, the gold, so converted into soluble chloride, then being deposited on a cathode. The process would seem to be hopeful, but is not as yet a serious rival to the ordinary chlorination method. In the amalgamation of gold ores much is expected from the possibility of keeping clean, by the aid of hydrogen set free by the electric current, the surfaces of amalgamated plates.

It is well known that the late Sir W. Siemens considered that the electric arc might render good service in the fusion of metals with high melting points, and he actually succeeded in melting 96 oz. of platinum in ten minutes with his electrical furnace. The experiments were interrupted by his untimely death, but in the hands of Messrs. Cowles the electric arc produced by 5,000 amperes and 500 horse power is being employed on a very large scale for the isolation of aluminum, from corundum, which is immediately alloyed—*in situ*—with copper or iron, in the presence of which it is separated. The heating power of large currents has been used by Elihu Thomson in the United States, and by Barnardos in Russia, to weld metals, and it is said to weld steel without affecting its hardness. It has even been proposed to weld together in one continuous metallic mass the rails of our railways, so as to dispense entirely with joints.

The production of chlorine for bleaching and of iodine for pharmaceutical purposes, the economical production of oxygen, are also processes now dependent on the electrolytic effect of the electric current. It is almost impossible to enumerate the various general purposes to which electricity is applied to minister to our wants and to add to our comforts. Every one appreciates the silent efficiency of the trembling electric bell, while all will sooner or later derive comfort from the perenially self-winding electric clock. Correct mean time is distributed throughout the length and breadth of the land by currents direct from Greenwich observatory. Warehouses and shops are fitted with automatic contact pieces, which, on any undue increase of temperature due to fire, create an alarm in the nearest fire station; and at the corner of most streets a post is found with a face of glass, which on being broken enables the passer-by or the watchful and active policeman to call a fire engine to the exact spot of danger. Our sewers are likely to find in its active chemical agency a power to neutralize offensive gases, and to purify poisonous and dangerous fluids. The germs of disease are attacked and destroyed in their very lairs. The physician and the surgeon trust to it to alleviate pain, to cure disease, to effect organic changes beyond the reach of drugs. The photographer finds in the brilliant rays of the arc lamp a miniature sun, which enables him to pursue his lucrative business at night, or during the dark and dismal hours of a black November fog of London.

We learn from the instructive and interesting advertising columns of our newspapers that "electricity is life," and we may, perhaps, read in the more historical portion of the same paper that by a recent decision of the New York parliament, "electricity is death." It is proposed to replace hanging by the more painless and sudden application of a powerful electrical charge; but those who have assisted at this hasty legislation would have done well to have assured themselves of the practical efficacy of the proposed process. I have seen the difficulty of killing even a rabbit with the most powerful induction coil ever made, and I know those who escaped and recovered from the stroke of a lightning discharge. The fact that the energy of a current of electricity, either when it flashes across an air space or when it is forced through high resistance, assumes the form of heat of very high temperature led early to its employment for firing charges of gunpowder; and for many civil, military, and naval purposes it has become an invaluable and essential agent. Wrecks like that of the Royal George at Spithead were blown up and destroyed; the faces of cliffs and quarries are thrown down; the galleries of mines and tunnels are excavated; obstructions to navigation like the famous Hell Gate, near New York, have been removed; time guns to distribute correct time are fired by currents from Greenwich at 1 P.M. In the operations of war, both for attack and defense, submarine mining has become the most important branch of the profession of a soldier and a sailor. Big guns, whether singly or in broadside, are fired, and torpedoes, when an enemy's ship unwittingly is placed over them, are exploded by currents of electricity. An immense amount of research has been devoted to design the best form of fuse, and the best form of generator of electricity to use to explode them. Gun tubes for firing consist of a short piece of very fine wire embedded in some easily fusible compound, while the best form of fuse is that known as the Abel fuse, which is composed of a small compact mass of copper phosphide, copper sulphide, and potassium chlorate. The practice in the use of generators is very various. Some, like the Austrians, lean to the high tension effects of static electricity; others prefer magneto machines; others use the dynamo; while we in England cling with much fondness to the trustworthy battery.

Since the electric light has also become such a valuable adjunct to war purposes, it is probable that secondary batteries will become of immense service. The strong inductive effects of atmospheric electricity are a source of great danger. Many accidental explosions of fuses have occurred. An experimental cable with a fuse at one end was laid below low water mark along the banks of the Thames at Woolwich. The fuse was exploded during a heavy thunderstorm. The knowledge of the causes of a danger is a sure means for the production of its removal, or of its reduction to a minimum. Low tension fuses and metallic circuits reduce the evils of lightning, but have not removed them. Should war unhappily break out again in Europe, submarine mining will play a very serious part, and, paradoxical as it may appear—as has been suggested by the French ambassador, M. Waddington—its very destructiveness may ultimately prove it to be a powerful element of peace.

It seems incredible that, having utilized this great power of nature to such a wide and general extent, we should still be in a state of mental fog as to the answer to be given to the simple question, What is electricity?

The engineer and the physicist are completely at variance on this point. The engineer regards electricity, like heat, light, and sound, as a definite form of energy, something that he can generate and destroy, something that he can play with and utilize, something that he can measure and apply. The physicist—at least some physicists, for it is difficult to find any two physicists that completely agree with each other—regards electricity as a peculiar form of matter permeating all space as well as all substances together with the luminiferous ether which it permeates like a jelly or a sponge. Conductors, according to this theory, are holes or pipes in this jelly, and electrical generators are pumps that transfer this hypothetical matter from one place to another. Other physicists, following Edlund, regard the ether and electricity as identical, and some, the disciples of Helmholtz, consider it as an integral constituent of nature, each molecule of matter having its own definite charge, which determines its attraction and its repulsion. All attempts to revive the Franklinian or material theory of electricity have, however, to be so loaded with assumptions, and so weighted with contradictions, that they completely fail to remove electricity from the region of the mysterious. It is already extremely difficult to conceive the existence of the ether itself as an infinitely thin, highly elastic medium, filling all space employed only as the vehicle of those undulatory motions that give us light and radiant heat. The material theory of electricity requires us to add to this another incomprehensible medium embedded or entangled in this ether, which is not only a medium for motion, but which is itself moved. The practical man, with his eye and his mind trained by the stern realities of daily experience, on a scale vast compared with that of the little world of the laboratory, revolts from such wild hypotheses, such unnecessary and inconceivable conceptions, such a travesty of the beautiful simplicity of nature. He has a clear conception of electricity as something which has a distinct objective existence, which he can manufacture and sell, and something which the unphilosophic and ordinary member of society can buy and use. The physicist asserts dogmatically: "Electricity may possibly be a form of matter—it is not a form of energy." The engineer says distinctly: "Electricity is a form of energy—it is not a form of matter; it obeys the two great developments of the present generation—the mechanical theory of heat and the doctrine of the conservation of energy." There must be some cause for this strange difference of views. It is clear the physicist and the engineer do not apply the term electricity to the same thing. The engineer's electricity is a real form of energy; the speculative philosopher's electricity is a vague, subjective unreality which is only a mere factor of energy, and is not energy itself. This factor, like force, gravity, life, must, at any rate for the present, remain unknowable. It is not known what force is; neither do we know what is matter or gravity. The metaphysician is even doubtful as regards time and space. Our knowledge of these things commences with a definition. The human mind is so unimpressionable, or language is so poor, that writers often cannot agree even on a definition. The definition of energy is capacity for doing work. We practical men are quite content to start from this fiducial line, and to affirm that our electricity is a something which has a capacity for doing work: it is a peculiar form of energy. The physicist may speculate as much as he pleases on the other side of this line. He may take the factors of energy, and mentally play with them to his heart's content; but he must not rob the engineer of his term electricity. It is a pity we cannot settle our difference by changing the term. Physicists might leave the term electricity to the form of energy, which is an objective reality, and which the ordinary mortal understands; while engineers would be quite content if speculative physicists and enthusiastic mathematicians would call their subjective unreality, their imaginary electrical matter, by some other term. If it be necessary to mentally create some imaginary matter to fulfill the assumptions and abstractions of their mathematical realizations, let them call it coulombism or electron, and not appropriate the engineer's generic and comprehensive term, electricity. The engineer finds the motions of existing matter and of the ether quite sufficient to meet all his requirements, and to account for all those phenomena which are called electrical.

It seems paradoxical to assert that two unrealities can form a reality, or that two subjective ideas can become an objective one; but it must be remembered that in all electrical phenomena, that which makes them real and objective is derived from without. The motion that renders an electrical phenomenon evident is imparted to it from some other form of energy. The doctrine of the conservation of energy asserts that energy is never destroyed, it is only transformed—work must be done to render it evident. No single electrical effect can be adduced which is not the result of work done, and is not the equivalent of energy absorbed. The engineer's notion of work—something done against resistance—and of power—the rate at which this change of condition is effected—are the keystones to the conception of the character of those great sources of power in nature whose direction to the uses and convenience of man is the immediate profession of those who generally assemble together in Section G of the British Association to discuss the "practical application of the most important principles of natural philosophy, which has, in a considerable degree, realized the anticipations of Bacon and changed the aspect and state of affairs in the whole world."

I cannot pretend to have given a survey of all the practical applications of electricity. I have but briefly indicated the present area covered by the new and rapidly growing industry. Five million people upon the globe are now dependent on the electric current for their daily bread. Scarcely a week passes without some fresh practical application of its principles, and we seem to be only on the shore of that sea of economy and beneficence which expands with every new discovery of the properties of electricity, and spreads already beyond the mental grasp of any one single worker.

ELECTRICAL CONDUCTIVITY OF METALS.

THE fact that the electrical conductivity of the various metals is in the same relative order as their heat conductives is a commonplace of the text books, but Prof. Kundt has recently shown (*Phil. Mag.*, July, 1888) that the analogy also extends to the velocity of light in metals. This velocity is easily calculated when we know the index of refraction. Hitherto the indices of refraction have only been known for certain metals, and by indirect methods of observation, but Prof. Kundt has succeeded by means of electrolytic deposition in preparing metallic prisms of very small angle and sufficiently transparent to admit of the direct measurement of the refractive indices. The relative velocities of red light in seven metals, calculated from these observations, are as follows:

Silver	100	Iron	14·9
Gold	71	Nickel	12·4
Copper (impure)	60	Bismuth (crystallized	10·3
Platinum	15·3		

The order will be seen to be the same as that of the relative conductivities. The number 60 for copper appears to be too small, but Prof. Kundt thinks that this is probably due to the existence of traces of cuprous oxide in the prism. He is now engaged in investigating the influence of a magnetic field upon the velocity in question.

DESCRIPTION OF AN UNDERGROUND CONDUIT.*

By ALEX. CRAWFORD CHENOWETH.

THE changing of electric light conductors to an underground system having engaged the attention of this meeting, I will place before you a method of constructing ducts that can be so arranged as to meet many of the objections heretofore presented.

The object of this paper is not for the purpose of discussing the merits or demerits of systems that have already been presented, but to invite your criticism of the practical points of the method I am about to describe.

Assuming the subject of insulation has been settled, and that an arrangement of the conductors in a structure permanently located, and so contrived that as demands from time to time are made for its use, it can be augmented at a small cost, this being done in order to meet the financial question of cost.

The material from which to build these structures must withstand the forces of nature that are brought into action in their new relations. I have found concrete, being a mixture of Portland cement and sand in suitable proportions, well incorporated, answer all the requirements.

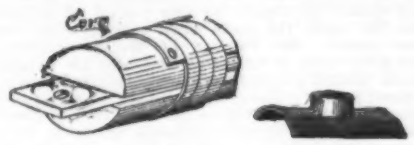
The form of the structure requires a system consisting of ducts four inches in diameter, with large manholes located at convenient points for purposes well established in previous discussions, with other entrances to the ducts, through openings located at intervals, to be used when required as connecting points to houses and stores. All parts should be constructed with smooth interior, free from joints, faults, depressions, and water-tight.

The structure is formed by means of a core which consists of a wooden cylindrical rod, made in lengths of fourteen feet or twenty feet, being cut in two, forming two half cylinders. The space removed by sawing through the rods, when each of the halves are placed together, is occupied by an iron rod, having a thickness equal to the portion removed by saw, restoring the cylindrical shape; this forms the mandrel or core.

Now, a ribbon of galvanized iron, one inch wide and of a thickness equal to twenty-seven gauge, is wound spirally around the mandrel of wood from end to end, securing the ends with a fastener to the wood, to prevent unwinding. The outside of the core is now painted with a mixture of clay, powdered soapstone, and water.

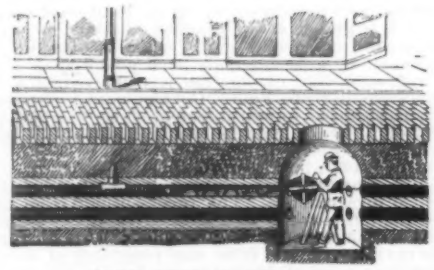
The core, as above described, is ready for use. Preparing a ditch, the core is placed in it, resting on cross pieces of wood. If more than one duct is to be constructed, other cores are ranged side by side. The concrete, in a plastic state, is now tamped well around, bringing the top to an even level. The iron rod is now removed, as well as the pieces of wood on which the ends of the core were resting, also the fastening of the ribbon ends. The wooden half cylinders are now drawn out, leaving the spiral casing, which remains for several days.

A new core is inserted in end of spiral; the ribbon of old core is fastened to ribbon of new core by a swivel, and you proceed in the same manner as before, thus constructing several hundred feet with the casing remaining in. When the cement hardens, the casing can be drawn out, being a spiral; this being done at any opening, man-hole, or unfinished portion of the work.



As the spiral ribbon is removed, the surface coating of clay and soapstone adheres to the interior of the duct, producing a smooth surface, and acting as a lubricant to reduce friction when conductors are drawn in, preserving the insulation. This construction insures a monolithic structure, with smooth interior, straight, free from joints, depressions, and water tight by reason of its construction.

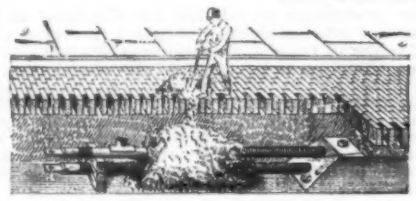
At the same time, in case you should require another duct, the wall on one side is always ready, by merely placing the core on top or on either side, and proceeding in the same manner. This reduces the cost of new duct. The most convenient arrangement for distribution purposes suggests a line of two holes on each side of street, with man-holes at intersecting streets, and openings at every house lot subdivision.



THE SPIRAL RIBBON.

I have adopted an opening in the form of a cast iron nozzle, with a hole into which a pipe can be screwed, by removing a screw plug, the same being set in the cement when constructing the duct, leaving the nozzle projecting only. This can be modified to suit any size or shape or replacing the nozzle with a box having a lid. This form of construction will permit the conduits to be placed near the surface, while the elasticity of the concrete enables it to withstand the blows caused by heavy traffic. It is an easy matter to project a conduit of this form from a man-hole to an insulated point, and afterward to construct others alongside at small cost.

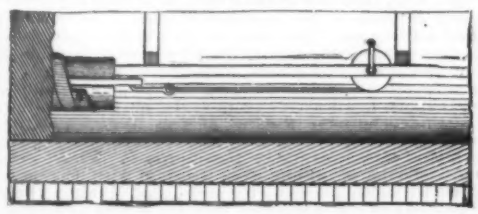
The cost of constructing ducts by this method is narrowed down to the winding of the ribbon on the mandrel, the labor of removing the mandrels in the



PACKING THE CONCRETE.

trench, removing the ribbon from duct, and rewinding the ribbon on bobbins.

As each part of the core is preserved and used an indefinite number of times, the cost of the core is charged to cost of plant, it costing ten cents per foot. The winding of the ribbon is done on the spot as fast as wanted, and costs five mills per foot; the cost of drawing out the ribbon and rewinding on bobbins, using an ingenious device that removes all twists, costing about one mill per foot, the labor for removing wooden mandrel in trench being about one cent per foot. A duct four inches in diameter, made of concrete, one of cement, two of sand, can be made for four cents per foot, including entire cost, exclusive of excavation, man-holes, and openings. In case a repair should be found necessary, a block can be made with a duct



DEVICE FOR WITHDRAWING THE CORE.

through it and inserted between the two ends thus to be joined, leaving a space of one inch at each end. Insert a spiral sleeve inside of duct made of iron, a wire fastened to the end of the ribbon forming the sleeve, also connected to sleeve at other end of block by wire; then extend to nearest opening. Pack the cement between the ends firmly, the sleeve preventing the cement from entering conduit, and when cement forming the joint becomes hard, the sleeves can be removed by hauling on the wire at the opening and removing the same.

* A paper read before the recent New York convention of the National Electric Light Association.

THE BRITTLENESS INDUCED IN IRON BY PICKLING.

By Professor A. LEDEBUR.

THIS memoir records a long series of experiments upon the strength of wires of iron and moderately soft steel, which have been subjected to the action of water acidulated with sulphuric acid in order to remove scale from the surface. The fact that wire so heated becomes extremely brittle from the absorption of hydrogen was first published by Professor Hughes, F.R.S., in 1880, and subsequently, in 1887, Mr. Dittmar, of Aachen, called attention to the fact that this brittleness gradually disappears when the pickled wire is left at rest for some time. The author's experiments were conducted with eight different qualities of wire, the respective compositions of which were:

No.		C. Per Cent	Si. Per Cent	P. Per Cent	Ma. Per Cent
1	Charcoal iron wire, unannealed	Undetermined	.	0·06	....
2	Soft ingot iron	0·06	0·08	0·16	0·18
3	Semi-soft ingot iron	0·27	0·15	0·11	0·49
4	Puddled iron wire, annealed	Undetermined	....	0·07	....
5	Puddled iron wire, semi-soft	Undetermined	....	0·20	....
6	Patent cast steel wire, unannealed	0·43	0·01	0·03	0·25
7	Patent cast steel wire, semi-soft	0·51	0·01	Undetermined	0·2
8	Extra tough steel wire	0·38	0·09	0·02	0·2

The wires were treated in different ways. First by pickling in 1 per cent. sulphuric acid water for twenty-four hours without previous cleaning, the tests being applied after three days; secondly, by pickling in 2½ per cent. acid for twenty-three hours, after cleaning the surfaces with ether, the mechanical tests being applied immediately; thirdly, by protecting the wire from direct attack by attaching a mass of zinc to one end, when a very rapid development of hydrogen takes place on the surface of the iron, which becomes brittle without being actually attacked, as previously demonstrated by Professor Hughes, and testing at once; while in a fourth series repeating the third treatment, the samples were only tested after four days' interval. The general result of these four series showed that, although the ultimate tensile strength of the wire was not diminished, but, if anything, slightly increased by pickling, the ductility, as measured by the ultimate extension, was reduced about 15 per cent., and the flexibility, as indicated by the number of bends producing fracture, by 39 per cent., or from 9·48 to 5·78 bends.

A fifth series of experiments showed that the original quality of the pickled wire was nearly restored by annealing it at a red heat in a current of carbonic oxide and nitrogen, the ultimate difference in ductility and flexibility between the black wire and that pickled and annealed being only 5·9 per cent. in extension, and 9·8 per cent. in the number of bends. Very weak acid, 1 to 200 of water, behaved similarly when the action was continued for some days, and the acid water from the Freiberg mines also had some slight effect in producing brittleness. A very decided deterioration was also produced by exposing the wires to atmospheric oxidation for about two months, their ultimate extension and bending flexibility being reduced by about one-half in both. When, however, the freely exposed wires were protected from direct oxidation by coating the ends with zinc, only a very slight change took place in a fortnight. The influence of time in restoring the flexibility of pickled wire was tested by allowing samples to rest in dry air for four weeks before testing, when the loss of flexibility, which was at first 76·3 per cent., diminished to about 17·5 per cent. This change was not, however, accompanied with a corresponding recovery in ductility, as in most instances the brittleness was, if anything, rather increased. Subsequent experiments made with bars of spring steel of 0·65 to 0·9 per cent. carbon temper showed a loss of strength varying 20 to 40 per cent. due to pickling when subjected to a bending test. Cast iron was but very slightly affected by twenty-four hours' pickling in 2 per cent. acid water, but with 8 per cent. acid and nine days' exposure the transverse strength and flexibility were reduced from 11 to 19 per cent.

The author considers that the following five propositions are established by the result of the experiments:

1. In all cases where malleable iron is exposed to influences likely to generate hydrogen upon its surface, and more particularly to the action of weak acid, a change in its mechanical properties results, the modulus of tensile strength being unaltered so long as the metal is not sensibly corroded, but the extension under stress and the capacity of resisting bending strains are notably diminished. In consequence of these changes the iron can be more easily broken, either by repeated bending or by simple bending strains, than in the original state.

2. An action similar to that of weak acid is produced by the atmosphere when iron is exposed to it in an unprotected condition.

3. Contact of the iron with zinc, which renders the former electro-negative, has a notable effect in increasing the influence of the acid on the unprotected portion of the surface, so that a very much shorter time suffices to produce brittleness than without such contact.

4. The brittleness produced by pickling or rusting is removed by annealing, and also disappears, or is considerably diminished, by allowing the brittle metal to rest for some time in a perfectly dry place. It cannot, however, be removed by mechanical treatment in the cold.

5. Cast iron is not sensibly, or only very slightly, affected by pickling.

Finally, the author made some direct determination of the hydrogen contained in the brittle wire. For this purpose four samples of charcoal iron wire, weighing from 60 to 75 grammes, were, after pickling, heated to redness in a current of nitrogen, the gas expelled oxidized by cupric oxide, and the resulting water col-

lected in anhydrous phosphoric acid. The results obtained were as follows:

	Hydrogen, Per Cent.
Wire of 2·5 millimeters	0·0021
" " 2·5 "	0·0028
" " 3 "	0·0052
" " 3 "	0·0035

Although the presence of hydrogen has thus been established in the pickled wire, it seems at first sight doubtful whether such minute quantities can be sufficient to produce the very remarkable changes in the mechanical properties demonstrated by the experiments. In considering this point, the author suggests that the influence of a foreign substance upon iron may be determined not so much by the weight as by the number of atoms present, and, therefore, that hydrogen, whose atomic weight is only $\frac{1}{31}$ that of phosphorus, the element which it most nearly simulates in effect, may be sufficient to produce very decided brittleness, even when present in scarcely appreciable quantity.—*Stahl und Eisen*, 1887, *page* 682, *through Proc. Inst. Civ. Eng.*

THE IRON AND COAL MINES OF ALABAMA.

A CORRESPONDENT of *Engineering*, who accompanied the members of the American Institute of Mining Engineers during their recent visit to the various mines in the region of Birmingham, says: The Thomas mines were first examined, and the almost inexhaustible supply of ore astonished the visitors; the climax was reached when at these mines, at Redding, a vein of Clinton ore varying from 10 ft. to 30 ft. in thickness was shown; the annexed engraving shows this very remarkable formation.

From this the thickness of the ore can readily be seen, and the writer was informed the vein continues some 10 to 12 miles with varying thickness. The vein we inspected extended back three-quarters of a mile, and it is mined to about 300 ft. from the surface, and

IRON ORE DEPOSITS AT REDDING, ALABAMA.

the output is 1,000 tons daily. For 100 ft. it is soft red ore, with little or no lime carbonate, and averages 50 to 55 per cent. of iron; for the next 100 ft. the carbonate increases rapidly, the proportions being 25 to 35 per cent. of iron and 40 to 45 per cent. of carbonate. This ore is known as the hard red ore, and it is not infrequent practice to mix these ores in equal parts in the furnace, using no additional limestone. The ore mined is shipped 11 miles, and costs 75 cents per ton, 25 of which are freight charges. Wages here are from $1 to $1.25 per day, the men being mostly negroes. We found here the Rand drill, 18 in. by 20 in., and the duplex compressor, which, as usual, is doing very satisfactory work. Other mines were visited that afternoon, and the *Herald* reporter circulated among the members, trying to get their opinions of their visit, which naturally were extremely favorable; so the next day the party was dubbed "capitalists and scientific men of national repute," which ought to be sufficient reward. Among other papers read that evening was one by Professor W. P. Phillips on "Phosphate Slag," in which he recommended its use as a fertilizer, stating the Southern States spent $10,000,000 annually for phosphoric acid, and that phosphoric slag would yield it at a far lower price.

The next day the party went to Ensley, stopping at the mines of the Pratt Coal and Coke Company. This organization had a wonderful history, growing out of a small coal tract taken by a Northern gentleman in payment of a bad debt. Being a mining engineer, he soon discovered a lower vein hitherto overlooked, and from this has grown a great industry with a capital of several millions of dollars. The vein is about 4 ft. 9 in. thick, and although there was a strike in process, yet evidences appeared of prosperity and future profits. The daily output was 3,000 tons, and coal-cutting machines were in use. The coal makes a hard and firm coke well suited to sustain the iron ore, and was pronounced by experts to be of very fair quality. From this place the party inspected the Ensley furnaces of the Tennessee Coal and Iron Company, one of the greatest institutions in the South, and in which there is considerable English capital invested. One of their officials told your correspondent that it took him just five weeks to inspect their various plants, and that at the conclusion of the inspection it was necessary to begin again on the furnace first examined. It was at the Ensley furnace we saw iron being shipped before it was cold, and so warm was it that leather gloves were used in handling it; which brings to mind a remark of our dear old Holley to Mr. Sydney Gilchrist Thomas, when the latter in his enthusiasm over the Bessemer process remarked: "Holley, I could sit all day long on an ingot mould and see the steel run." "Well," said Holley, "you'll have to send to England to get one cool enough to sit on."

This great company, with a capital of $10,000,000, controls the following:

Three furnaces at South Pittsburg, Tenn., one of them having been completed and blown in during March; two at Birmingham, one at Cowan, and it is building four at Ensley City, three of which are nearly finished, besides the extensive coal mines in the South. At the Tracy City division the output of coal was 426,274 tons, of which 257,685 tons were converted into coke. The profits of this division were $94,709.31. At the Pratt mines 718,824 tons of coal were mined, the profits being $185,721.75, while a number of new coal and ore mines have also been opened to supply the new furnaces under construction.

The four-furnace plant at Ensley received careful attention. Each stack is 80 ft. by 200 ft., being the largest in the South; only one was in blast, and the output was 160 tons daily. The second stack was to be blown in that week. At Ensley we found a nice club house and a number of pretty residences, while the town itself was laid out on a grand scale. There were avenues 100 ft. in width laid out, with numerous streets intersecting them at right angles. In the judgment of the writer a much prettier effect is obtained by laying out curved streets, and thus avoiding a certain stiff regularity. The Institute was entertained nicely at the club, and some of the ladies liked the location so well that a party was formed that remained there overnight.

The Ensley Land Company, which is the Tennessee Coal and Iron Comrany in point of fact, has a most ingenious method of disposing of its property. Inducements to settle there are offered to manufacturers of standing, and a sale of lots is made, the proceeds of which are loaned to such manufacturers as will agree to employ only such workmen as will purchase a lot and live on the land. The scheme looks well and seems to promise success. After dinner the party went to Bessemer, stopping *en route* at the Woodward Iron Company's plant. Bessemer is known as the "Marvel City," and well deserves the title.

On April 12, 1887, there was nothing of Bessemer but a primeval forest, and some 300 people had gathered, mostly out of curiosity, to see the sale of lots advertised. A large hotel was speedily erected, being the building used at the New Orleans Exposition for the Mexican exhibit, and called the "Montezuma." In ten months what was the result? The population numbered 4,000. There are seven lines of railroad running to the city, and 350 buildings of considerable size have been erected.

Among the principal buildings are the following: The Adler block, 100 ft. front and three stories high, of brick with iron pillars and cornices; several banks built of pressed brick and decorated with stained glass, cut stone, etc.; the Charleston block, built of brick and marble, and costing $125,000, extending 300 ft. by 100 ft. deep; the Grand Hotel, of brick, cut stone, and terra cotta, costing $50,000; and the Palmetto block, also 300 ft. front by 100 ft. deep. There are several other hotels, and many other handsome buildings; there are besides churches enough to satisfy all denominations and all shades of doctrine.

Five large real estate agencies flourish here, having capital varying from $1,200,000 to $200,000, and concessions are made to any reputable industry desiring to locate. As an evidence of the labor going on here, it may be stated that the pay roll within the city limits is $100,000 per month, and within three miles of it $150,000 per month. Terms for land are usually a quarter cash and the balance in yearly payments for four years, the interest being (think of it, Mr. Goschen) 8 per cent. This city supports, among other industries, a 28-column daily paper and has a most industrious staff of reporters. Our party was "interviewed," and our family history laid open to this little city. We found it best to tell these reporters something, or else they put in what they chose. This conclusion was a matter of experience, just as the guest preferred to have the waiter bring him a plate of butter and a plate of flies, "for," said he, "they mix better when one has control of both ingredients," and we mixed up our own notices in just this manner. There are two new furnaces building, and a rolling mill of a capacity of 125 tons per day; this mill will employ 600 men and contain 24 puddling furnaces. The Bessemerists say they will have 15,000 people there within a year, but no doubt they say a great many things besides their prayers; still it is a "Marvel City."

The day following, the Institute was filled with such science as its capacity could absorb during the morning, and in the afternoon some of us went to the Gates City Rolling Mill and the Trussville Furnace. One thing we saw of interest was the new coke ovens just erected by the Tennessee Coal and Iron Company, a description of which will prove interesting to your readers. They are being constructed by Mr. Richard Thomas, of Carbondale, Ill., at No. 3 mine, and consist of a plant of 63 of his patent coke ovens. This is a new oven, for which great advantages over the beehive form are claimed. Each oven is 6 ft. wide, 36 ft. long, and 5 ft. high in the clear. A 14 in. wall divides the ovens. They are charged from the top the same as a beehive oven, taking a charge of 12 tons to each oven. Steam machinery, mounted on wheels, will be run in front of the ovens for drawing out the charge after the coke is made. The mouth of the oven is a few inches wider than the back part, permitting the charge to slide out freely. When the charges are drawn, the oven can be recharged immediately, thus keeping them at a greater heat and making a better quality of coke. This will be the first of this class of ovens built in this part of the South, and the result will be anxiously looked for by others interested in coke making. When all four of their furnaces are in blast, it will require a large amount of coal from these mines daily to keep them supplied with coke. The steam ram is used to empty them, shoving out the entire charge into a sheet iron car, which has an overhead sprinkler This is turned on, the coke thoroughly drenched, after which it is pushed off this car and allowed to fall into a gondola railroad car some feet below, and is thus broken up. We do not wish to be too critical on a new enterprise, but the coke was not so cool but that it set fire to the car several times; otherwise the matter may have been said to be "successful." As a medical friend once said in describing an operation to a class of students in the hearing of the writer: "Gentlemen, this was one of the most beautiful and successful operations it has ever been my good fortune to witness; true, the patient died under it, but then that would have occurred in any event." So we had no doubt the burning of the car would have happened in the ordinary process, and it was plainly the duty of the railroad company to furnish cars. The coke was of good quality, and seemed firm and brittle. It was claimed in one of the papers read that this coke was better than that of Chattanooga.

That night ensued a flow of wit and a general good time, known as the annual dinner. Our scintillating secretary was at his best, and that means every one had a good time.

The next day the party went to Blockton on a special train to visit the Cahaba coal mines, stopping on the way to see slope No. 5 of the De Bardeleben coal mines, where they went into the hill about 1,300 ft., and beheld a fine vein of coal.

At Blockton we had a fine opportunity of seeing the choicest piece of coal property in the State of Alabama. Mr. T. H. Aldrich is the president of this company, and its success is largely due to his wonderful enterprise, shrewdness, and good business management. This gentleman is from the North, and has been here about seven years, in which time he placed himself in the foremost ranks of Southern workers. The property lies in three counties, and consists of 36,000 acres of well timbered coal ground. Under Mr. Aldrich's direction railroads have been built to various portions, and the different veins developed. Six mines are now

in operation and two seams of coal are being worked, the one of 6 ft. with no parting and the other or lower vein of 3 ft. to 3½ ft. All the latest and best machinery is employed and every effort to save labor is made. The capacity of the various mines at present worked is 2,500 tons per day. The company had just completed 300 beehive coke ovens, and samples of their output were shown which completely justified the statement Mr. Aldrich had made at Birmingham, to the effect that there was no difficulty in making good coke if the operators would only see that the material was properly selected, and that the working was made with judgment. In other words, if sufficient pains were taken. He showed a firm, clean, and brittle sample not unlike the famous Connellsville coke, and it was by far the best in appearance we had seen in the South. The entire product of these ovens is already contracted for, and it was pronounced by all to be satisfactory in the highest degree.

The mines are being worked on scientific principles and the best modern appliances for ventilating and for pumping are being employed. The company employs 750 men and owns four locomotives, three of which are Baldwin Moguls. The following analysis of the coal and coke produced will be found of interest:

Analysis of Coal and Coke of the Cahaba Coal Mining Company.

Coal from "Woodstock" or 3 ft. seam:

Fixed carbon	55·76
Volatile matter	41·04
Ash	3·20
	100·00
Sulphur	1·01

Coal from "Underwood" or 6 ft. seam:

Moisture	2·24
Volatile matter	34·12
Fixed carbon	60 75
Ash	2·41
Sulphur	0·48
	100·00

Coke from "Underwood" seam:

Volatile hydrocarbon	4·508
Fixed carbon	87·607
Sulphur	0·745
Ash	7·140
	100·000

To give your readers an idea of the future of the coke business in this State, it may be said that at present there are 1,673 ovens in use, and 1,600 more contracted for, and that the output of almost all of them is already engaged.

On leaving the Cahaba mines the party went to see the ore beds of the Thomas Furnace Company. A small opening had been made by cutting the face of the hill, and two horses and carts were being loaded with the ore, which was dumped into a hopper and mixed, crushed, screened, and dropped into a car. The property consisted of 600 acres, and the richness of the ore made more than one furnaceman sigh and regret it was not nearer Pittsburg.

The next day the party started for Anniston, and with the exception of a delay caused by a broken flange, which threw the train off the track, they arrived in comfort. When the car was bumping on the ties, some of the gentlemen, who were white as a sheet (rather a rare occurrence in the South), besought the ladies, who were perfectly cool, not to be frightened, which, to say the least, was amusing. The road, however, was in good order, and is not the one where the passenger congratulated the conductor that the train was running so much more smoothly than it had a mile or two back, and was told, "Oh, yes! we are off the track now." Anniston is called the "Model City," and certainly has a beautiful hotel, called the Anniston Inn. In 1872 the Woodstock Coal and Iron Company, with a capital of $140,000, started. They built a 50 ton charcoal furnace, and in 1879 another; in 1881 this company formed another, with a capital of $250,000, and built a cotton factory with 12,000 spindles. In 1882 car works were built, streets macadamized, electric light plants installed, and a $40,000 church erected; within the next three years $2,000,000 had been expended and a 60 mile narrow gauge railway built. In the latter part of 1886 coke furnaces were built, at a cost of $500,000, with a capacity of 100,000 tons per annum. They also put $1,500,000 into the Cahaba Coal Company, and are building gas and water pipe works at present, to employ 900 hands and turn out 200 tons of iron pipe daily. Another railroad is being built at a cost of $1,000,000, which will give Anniston a closer connection with the West. But a short time since the United States Rolling Stock Company offered to establish an immense car works, employing 1,000 skilled mechanics, provided the present car works could be secured as a nucleus at $225,000, and that the Anniston people would contribute $150,000 to the cash capital of $1,000,000, making a total from Anniston of $375,000, and this was done at once.

The following improvements, according to the *Manufacturer's Record*, are being made: A new foundry, 130 ft. by 84 ft.; the axle forge doubled in capacity; a machine and blacksmith shop, 825 ft. by 105 ft.; paint shop, 325 ft. by 96 ft.; car repairing shop, 500 ft. by 96 ft.

The wood-working shop, which is arranged to take the rough lumber in at one end and turn out from twenty to twenty-five cars daily from the other, is 1,000 ft. by 105 ft.; this building is fitted with wood-working machinery from Fay & Co., of Cincinnati, O., and with engines of 500 horse power. The blacksmith shop has 225 horse power engines and machinery supplied by Bement, Miles & Co. A new rolling mill to roll 40 tons a day is to be constructed. The works, when in full operation, will employ 1,000 mechanics. And no debt has been incurred in all this, nor have any township bonds been issued.

The town has three banks with ample capital. No wonder, then, they call it the "Model City." Certainly it may be considered a model for any country to follow.

[NATURE.]

TIMBER, AND SOME OF ITS DISEASES.*

By H. MARSHALL WARD.

X.

IT may possibly be objected that the subject of the present paper cannot properly be brought under the title of these articles, since the disease to be discussed is not a disease of timber *in esse*, but only of timber *in posse*; nevertheless, while acknowledging the validity of the objection, I submit that in view of the fact that the malady to be described effects such important damage to the young plants of several of our timber trees, and that it is a type of a somewhat large class of diseases, the slight impropriety in the wording of the general title may be overlooked.

It has long been known to forest nurserymen that when the seedling beeches first appear above the ground large numbers of them die off in a peculiar manner—they are frequently said to "damp off" or to "rot off." A large class of diseases of this kind is only too familiar, in its effects, to cultivators in all parts of the world. Every gardener, probably, knows how crowded seedlings suffer, especially if kept a trifle too damp or too shaded, and I have a distinct recollection of the havoc caused by the "damping off" of young and valuable cinchona seedlings in Ceylon.

In the vast majority of the cases examined, the "damping off" of seedlings is due to the ravages of fungi belonging to several genera of the same family as the one (*Phytophthora infestans*) which causes the dreaded potato disease—*i. e.*, to the family of the Peronosporeæ—and since the particular species (*Phytophthora omnivora*) which causes the wholesale destruction of the seedlings of the beech is widely distributed, and brings disaster to many other plants; and since, moreover, it has been thoroughly examined by various observers, including De Bary, Hartig, Cohn, and others, I propose to describe it as a type of the similar forms scattered all over the world.

It should be premised that, when speaking of this disease, it is not intended to include those cases of literal damping off caused by stagnant water in ill-drained seed beds, or those cases where insufficient light causes the long-drawn, pale seedlings to perish from want of those nutrient substances which it can only obtain, after a certain stage of germination, by means of the normal activity of its own green cotyledons or leaves, properly exposed to light, air, etc. At the same time it is not to be forgotten that, *as conditions which favor the spread of the disease to be described*, the above factors and others of equal moment have to be taken into account; which is, indeed, merely part of a more general statement, viz., that to understand the cause and progress of a disease, we must learn all we can about the conditions to which the organisms are exposed, as well as the structure, etc., of the organisms themselves.

First, a few words as to the general symptoms of the disease in question. In the seed beds it is often first noticeable in that patches of seedlings here and there begin to fall over, as if they had been bitten or cut where the young stem and root join, at the surface of the ground; on pulling up one of the injured seedlings, the "collar," or region common to stem and root, will be found to be blackened, and either rotten or shriveled, according to the dampness or dryness of the surface of the soil. Sometimes the whole of the young root will be rotting off before the first true leaves have emerged from between the cotyledons; in other cases, the "collar" only is rotten or shriveled, and the weight of the parts above ground causes them to fall prostrate on the surface of the soil; in yet others, the lower parts of the stem of the older seedling may be blackened, and dark flecks appear on the cotyledons and young leaves, which may also be turning brown and shriveling up. (Fig. 36.)

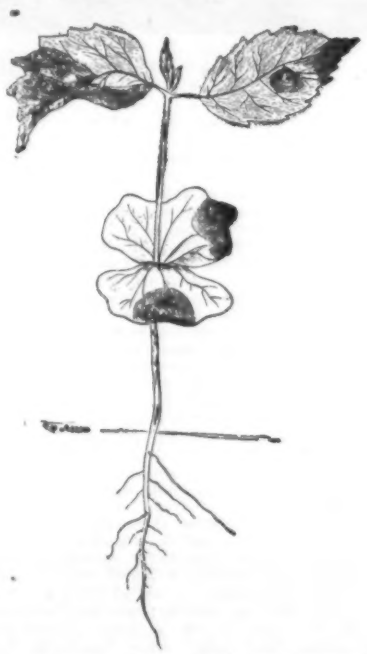


FIG. 36.—A young beech seedling attacked by *Phytophthora omnivora*: the moribund tissues in the brown and black patches on the young stem, cotyledons, and leaves are a prey to the fungus, the mycelium of which is spreading from the different centers. The horizontal line denotes the surface of the soil.

If the weather is moist—*e. g.*, during a rainy May or June—the disease may be observed spreading rapidly from a given center or centers, in ever-widening circles. It has also been noticed that if a moving body passes across a diseased patch into the neighboring healthy seedlings, the disease in a few hours is observed spreading in its tracks. It has also been found that if seeds are again sown in the following season in a seed bed which had previously contained many of the above diseased seedlings, the new seedlings will inevitably be killed by this "damping off." As we shall see shortly, this is because the resting spores of the fungus remain dormant in the soil after the death of the seedlings.

In other words, the disease is infectious, and spreads centrifugally from one diseased seedling to another, or from one crop to another; if the weather is moist and warm—"muggy," as it is often termed—such as often occurs in the cloudy days of a wet May or June, the spread of the disease may be so rapid that every plant in the bed is infected in the course of two or three days, and the whole sowing reduced to a putrid mass. In drier seasons and soils, the spread of the infection may be slower, and only a patch here and there die off, the diseased parts shriveling up rather than rotting.

If a diseased beech seedling is lifted, and thin sections of the injured spots placed under the microscope, it will be found that numerous slender, colorless fungus filaments are running between the cells of the tissues, branching and twisting in all directions. Each of these fungus filaments is termed a hypha, and it consists of a sort of fine cylindrical pipe with very thin membranous walls, and filled with watery protoplasm. These hyphæ possess the power of boring their way in and between the cell walls of the young beech seedling, and of absorbing from the latter certain of the contents of the cells.

This is accomplished by the hyphæ putting forth a number of minute organs like suckers into the cells of the seedling, and these suckers take up substances from the latter; this exhaustion process leads to the death of the cells, and it is easy to see how the destruction of the seedling results when thousands of these hyphæ are at work.

At the outer parts of the diseased spots on the cotyledons or leaves of the seedling, the above named hyphæ are seen to pass to the epidermis, and make their way to the exterior; this they do either by passing out through the openings of the stomata, or by simply boring through the cell walls. (Fig. 37.) This process of

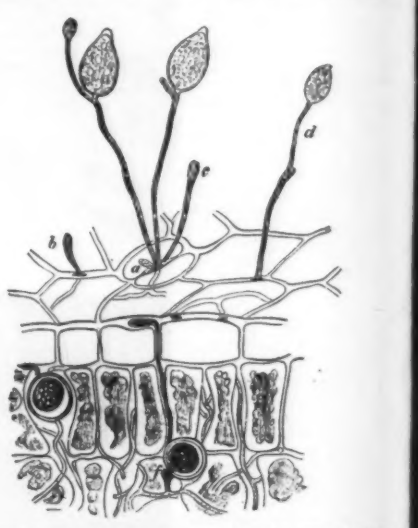


FIG. 37.—Portion of a cotyledon of the beech, infested with *Phytophthora omnivora*. The piece is shown partly in vertical section. The mycelium, spreading between the cells, puts forth aerial hyphæ, which bore between the cells of the epidermis, *b* and *d*, or emerge from the stomata, *a*, and form conidia at their apices; the various stages of development are shown. On other hyphæ, between the cells of the interior, the oospores are formed in oogenia, *e* and *f*. (Highly magnified.)

boring through the cell walls is due to the action of a solvent substance excreted by the growing tip of the hypha. The protoplasm secretes a ferment which passes out, and enables the tip to corrode or dissolve away the substance of the cell walls. It is also characteristic of these hyphæ that they make their way in the substance of the cell walls, in what is known as the "middle lamella." In this, and in what follows, they present many points of resemblance to the potato disease fungus, which is closely allied to *Phytophthora omnivora*.

The hyphæ which project from the epidermis into the damp air proceed to develop certain spores, known as the *conidia*, which are capable of at once germinating and spreading the disease. These conidia are essentially nothing but the swollen ends of branches of these free hyphæ. The ends swell up and large quantities of protoplasm pass into them, and when they have attained a certain size, the pear-shaped bodies fall off, or are blown or knocked off.

Now, the points to be emphasized here are, not so much the details of the spore formation, as the facts that (1) many thousands of these spores may be formed in the course of a day or two in warm, damp weather; and (2) any spore which is carried by wind, rain, or a passing object to a healthy seedling may infect it (in the way to be described) within a few hours, because the spore is capable of beginning to germinate at once in a drop of rain or dew. A little reflection will show that this explains how it is that the disease is spread in patches from centers, and also why the spread is so rapid in close, damp weather.

When a conidium germinates in a drop of dew, for instance, the normal process is as follows. The protoplasm in the interior of the pear-shaped conidium becomes divided up into about twenty or thirty little rounded naked masses, each of which is capable of very rapid swimming movements; then the apex of the conidium bursts, and lets these minute motile zoospores, as they are called, escape. (Fig. 38, *a*.)

Each zoospore then swims about for from half an hour to several hours in the film of water on the surface of the epidermis, and at length comes to rest somewhere. Let us suppose this to be on a cotyledon, or on the stem or root. In a short time, perhaps half an hour, the little zoospore begins to grow out at one point—or even at more than one—and the protuberance which

* Continued from SUPPLEMENT, No. 664, page 10614.

grows out simply bores its way directly through the cell wall of the seedling, and forms a cylindrical hypha inside (Fig. 38, *b*, *c*, *e*, *f*); this hypha then branches, and soon proceeds to destroy the cells and tissues of this seedling. The whole process of germination, and the entrance of the fungus into the tissues, up to the time when it in its turn puts out spore-bearing hyphæ again, only occupies about four days during the moist, warm weather in May, June, and early in July.

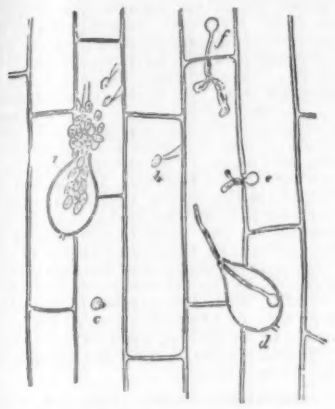


FIG. 38.—Portion of epidermis of a beech seedling, on which the conidia of the *Phytophthora* have fallen and burst, *a* and *d*, emitting the motile zoospores, *b*, which soon come to rest and germinate, *c*, by putting forth a minute germinal hypha, *c*, *e*, which penetrates between the cells of the epidermis, *e* and *f*, and forms the mycelium in the tissues beneath. At *d* a zoospore has germinated, without escaping from the conidium. (Highly magnified; partly after De Bary and Hartig.)

We are now in a position to make a few remarks which will enable practical people to draw helpful conclusions from what has been stated. Let us suppose a seed bed several feet long and about three feet wide, and containing some thousands of young beech seedlings; then suppose—by any means whatever—that a single conidium of *Phytophthora omnivora* is carried on to a cotyledon of one of the seedlings. Let us further assume that this occurs one warm evening in May or June. During the night, as the air cools, the cotyledon will be covered with a film or drops of water, and the conidium will germinate, and allow, say, thirty zoospores to escape. Now, the average size of a conidium is about $\frac{1}{150}$ of an inch long by about $\frac{1}{700}$ of an inch broad, and we may take the zoospore as about $\frac{1}{1000}$ of an inch in diameter. Thus it is easy to see that the film of moisture on the cotyledon is to a zoospore like a large pond or lake to a minnow, and the tiny zoospores, after flitting about in all directions, come to rest at so many distant points on the cotyledon—or some of them may have traveled abroad along the moist stem, or along a contiguous leaf, etc. Before daylight, each of these thirty zoospores may have put forth a filament which bores between the cells of the cotyledon, and begins to grow and branch in the tissues, destroying those cell contents which it does not directly absorb, and so producing the discolored disease patches referred to. Supposing the weather to remain damp and warm, some of the hyphæ may begin to emerge again from the diseased and dying seedling on the fourth day after infection—or at any rate within the week—and this may go on hour after hour and day after day for several weeks, each hypha producing two or more conidia within a few hours of its emergence; hence hundreds of thousands of conidia may be formed in the course of a few days, and if we reflect how light the conidia are, and how their zoospores can flit about to considerable distances, it is not surprising that many of them are shed on to the surrounding seedlings, to repeat the story. If we further bear in mind that not only every puff of wind, but every drop of rain, every beetle, or fly, or mouse, etc., which shakes the diseased seedling may either shake conidia on to the next nearest

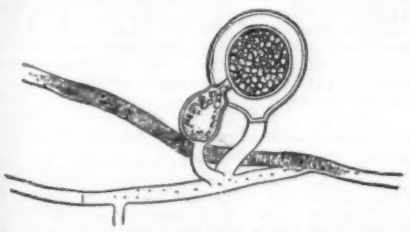


FIG. 39.—An oogonium and antheridium of *Phytophthora omnivora*. The oogonium is the larger rounded body, borne on a branch of the mycelium: it contains an oosphere, in process of being fertilized by the protoplasm of the antheridium (the smaller body applied to the side of the oogonium). The antheridium has pierced the wall of the oogonium, by means of a fertilizing tube, through which the contents pass into the oosphere, converting the latter into an oospore. (Very highly magnified; after De Bary.)

seedlings or even carry them further, it is clearly intelligible how the infection is brought about, and spreads through the seed bed, gathering strength as it were hour by hour.

But, although we have explained the rapid infection from plant to plant, it still remains to see how it is that if we sow the seeds in this bed next year, the seedlings are almost certain to be generally and badly attacked with the disease at a very early stage.

When the fungus-mycelium in the cotyledons and other parts of the diseased seedlings has become fully developed, and has given off thousands of the conidia above described, many of the branches in the dying tissues commence to form another kind of spore altogether, and known as an oospore, or egg-like spore. This spore differs from the conidium in size, shape, and position, as well as in its mode of development and further behavior, and if it were not that several observers have seen its formation on the same hyphæ as those which give rise to the conidia, it might be doubted by a beginner whether it really belongs to our fungus at all. As it is absolutely certain, however, that the oospore on germination gives rise to the fungus we are considering, the reader may rest satisfied on that point.

The spore in question is formed in a swelling of the free end of a branch of the hypha as follows: The protoplasm in the rounded end of the hypha becomes collected into a ball (the egg cell or *oosphere*) and then a smaller branch with a distinct origin applies itself to the outside of this rounded swelling and pierces its wall by means of a narrow tube: protoplasm from the smaller branch (*antheridium*) is then poured through the tube into the "egg cell," which thus becomes a fertilized "egg spore" or *oospore*. This *oospore* then acquires a very hard coating, and possesses the remarkable peculiarity that it may be kept in a dormant state for months, and even a year or more, before it need germinate; for this reason it is often called a resting spore. It has been found that about 700,000 oospores may be formed in one cotyledon, and a handful of the infected soil sufficed to kill 8,000 seedlings.

Now, when we know this, and reflect that thousands of these *oospores* are formed in the rotting seedlings and are washed into the soil of the seed bed by the rain, it is intelligible why this seed bed is infected. If seeds are sown there the next spring, the young seedlings are attacked as soon as they come up. These *oospores* are, in fact, produced in order that the fungus shall not die out as soon as it has exhausted the current year's supply of seedlings; whereas the *conidia*, which soon lose their power of germinating, are the means by which the parasite rapidly extends itself when the conditions are most favorable for its development and well-being.

It has already been mentioned that other plants besides the beech are destroyed by the ravages of this fungus. Not only has it been found to grow on herbaceous plants, such as *Sempervivum*, *Clarkia*, and many others, but it habitually attacks the seedlings of many timber trees, such as, for instance, those of the spruce and silver firs, the Scotch pine, the Austrian and Weymouth pines, the larch, the maples, and particularly those of the beech.

It is obvious that this makes the question of combating this disease a difficult one, and the matter is by no means simplified when we learn that the fungus can live for a long time in the soil as a saprophyte, and apart from the seedlings. In view of all the facts, let us see, however, if anything can be devised of the nature of precautionary measures. It must at least be conceded that we gain a good deal by knowing so much as we do of the habits of this foe.

In the first place, it will occur to everybody never to use the same seed bed twice; but it may be added that this precaution need not be taken as applying to anything but seeds and seedlings. Young plants, after the first or second year, are not attacked by the fungus—or rather are attacked in vain, if at all—and so the old beds may be employed for planting purposes. In the event of a patch of diseased seedlings being found in the seed bed, as in our illustration quoted above, the procedure is as follows: cover the whole patch with soil as quietly and quickly as possible, for obviously this will be safer than lifting and shaking the spore-laden plantlets. If, however, the sharp eye of an intelligent gardener or forester detects one or two isolated seedlings showing the early stages of the disease, it is possible to remove the single specimens and burn them, care being taken that the fingers, etc., do not rub off spores on to other seedlings.

In the last event, the beds must be looked to every day to see that the disease is not spreading. All undue shading must be removed, and light and air allowed free play during part of the day at least; by such precautions, carefully practiced in view of the above facts and their consequences, it is quite feasible to eradicate the disease in cases where ignorant or stupid mismanagement would result in the loss of valuable plants and time. In the case of other seedlings, also, much may be done by intelligently applying our knowledge of the disease and its cause. It is not our purpose at present to deal with the diseases of garden plants, etc., but it may be remarked in passing that in the large majority of cases the "damping off" of seedlings is due to the triumphant development of fungi belonging to the same genus as the one we have been considering, or else to the closely allied genus *Pythium*. In illustration of this I will mention one case only.

It is always possible to obtain well grown specimens of the fungus *Pythium* by sowing cress seed fairly thick, and *keeping the soil well watered and sheltered*. Now what does this mean? Nobody imagines that the fungus arises spontaneously, or is produced in any miraculous manner; and in fact we need not speculate on the matter, for the fact is that by keeping the crowded cress seedlings moist and warm we favor the development of the *Pythium* (spores of which are always there) in somewhat greater proportion than we do the development of the cress. In other words, when the cress is growing normally and happily under proper conditions, it is not because the *Pythium* is absent, but because (under the particular conditions which favor the normal development of healthy cress) it grows and develops spores relatively so slowly that the young cress seedlings have time to grow up out of its reach. The recognition of this struggle for existence on the part of seedlings is of the utmost importance to all who are concerned with the raising of plants.

THE LICK OBSERVATORY.

By EDWARD S. HOLDEN.

THE Lick Observatory has been officially "completed" for something like eleven weeks, but the first six of these were hardly available for regular observations. There were many changes to make in the preliminary arrangements in order to turn the observatory from a mere collection of buildings and instruments into a busy laboratory of work. We are even yet far from the last and highest state of efficiency, but, at least, our work is going on with full activity, and we see the way out of every difficulty yet remaining. The testing of the great photographic lens of thirty-three inches aperture is now in progress, and during the present lunation we have secured some exquisite pictures of the moon, several having been taken every night (for all the nights are clear in this astronomer's paradise).

These pictures are to form the first chapter, as it were, of a work on the moon, which seems to be admirably well worth doing in a systematic manner. As soon as we have completed the arrangements for enlarging the photographic pictures in the telescope itself, we shall proceed to study special regions and craters in detail by photographing them also every night, under all conditions of illumination, and enlarged about five to seven times. These enlarged pictures will give the craters on a scale of about twenty-five to thirty-five inches to the moon's diameter; and they will bear a second enlargement in the camera of perhaps two or three times more, so that finally we expect to be able to have photographs of certain regions of the moon on a scale of fifty or more inches to the diameter. These ought to present really important testimony in regard to the vexed questions of changes on the moon's surface and as to whether or no we have to regard the surface of our satellite as simply dead; since life is nothing but change.

It is rather the fashion among many practical astronomers to slight observations of the moon, as if nothing more was to be learned by such work. But I think that all of us have learned one lesson already in our use of the large telescope, and that is to look at every celestial object with a free and open mind, just as if we were seeing it for the first time. There is a kind of professional nonchalance which will not do here, unless we are willing to miss some golden opportunities. I have always admired the spirit of the section in Maedler's "Kurzgefasste - Beschreibung des Mondes" where he treats of the rather dangerous question of the inhabitants of the moon. He is not afraid to include such a subject in a strictly scientific work, and yet he treats it in a dignified and scientific manner. As this work is probably unknown to many of your readers, I venture to translate the section in question, which will be interesting from a literary as well as from a scientific point of view:

"Only with reluctance do I touch upon a second question, that of the inhabitants of the moon. Not that I would deny the great importance of the subject, or that an answer good for all future time would be impossible, but because the subject, on account of the careless way in which it has usually been treated in the past, has fallen into discredit with those who earnestly reason in a truly scientific spirit. I have discovered nothing certain in this matter—as little as others before me. I can entertain no hope of success in the future, and I cannot prevail upon myself to consider many uncertain and, in all probability, needless speculations. That everything created was made for wise and noble purposes is a thought which necessarily forces itself upon our consciousness. Again, as living matter fulfills higher and nobler purposes than that which is without life, so everywhere, when life is a possibility, we are really to assume its presence. In what has gone before, everything that has been said about the moon proves, it is true, that neither we, nor any living creature on our earth, could live on the lunar globe, but it by no means does away with the possibility of all and every form of life upon the moon, so that living forms are to be expected.

"But much that is indispensable to us is inaccessible to them, and, on the other hand, many things for which we have no name may be indispensable to the inhabitants of the moon. Their organs of sight must be adapted for stronger light, and they must be able to endure greater contrasts of light and darkness without injury. Just as little can their notions correspond to ours. In comparison with us it appears that they must be disproportionately lighter. How their days and nights are arranged, how the firmament appears to them, has already been stated in detail. All this, however, is insufficient to give us more than an imaginary picture of their form, height, mode of living, etc., and it will remain just as impossible to see as to reach them; even the idea of corresponding with them (although suggestions in that direction might not be wholly illusory) would seem to be just as far from realization. Works that would be similar to our own are probably not to be thought of, so that it will always remain a doubtful matter correctly to understand that which, in this respect, our telescopes might possibly show.

"Viewed in this light, our hopes as to better knowledge of the Selenites in the future are extremely scanty, and tend little to satisfy the impatient imagination of many an inhabitant of the earth. However, the object of our investigation of the heavens is by no means to be looked for in this direction. With reference to the moon in particular, there are questions to be answered which are of a totally different and, in fact, of a much more important nature. How was the moon created in the beginning? What finishing process did it undergo? Was the rotary motion always as it is now, or not? How did these motions harmonize with the position and magnitude of the axis? In what ways can the moon's influence be shown, and what laws govern these influences? These are only a few points about which we may in all probability expect information in the future, and will, if properly handled, furnish us more and better knowledge of the moon and its relation to the earth than could be obtained from a living Selenite, if we were able to lay hands on him."

We are extremely fortunate in having in our corps of astronomers two who are photographers of distinction—Mr. Burnham and Mr. Barnard. Together they constitute a most efficient working force, and have already obtained results of real value. Among the interesting things which have been done in this direction is Mr. Barnard's discovery that the 12 inch Clark equatorial, which was designed only for visual work, is in fact also a most efficient photographic telescope. Mr. Barnard has succeeded in making capital pictures of the moon, of the Pleiades, of the cluster in Perseus, of double stars, of Jupiter, etc., by its use, and we find the star images to be excellent over at least one degree. We have not tried more up to now. To utilize fully this instrument, a more powerful driving clock is needed, and one of our problems of to-day is how to get such an addition. We find it a misfortune to have the observatory reputed to be "completed," and would prefer it to be regarded as yet incomplete until we have tested its capabilities in every direction. Legal terms often stand in the way of rapid progress.

Perhaps the most generally interesting work of the large telescope has been done on the planet Mars. It will be in the memory of all that Professor Schiaparelli, of Milan, has devoted much time to a minute study of the surface features of this planet, and that lately he has reported a very interesting and novel phenomenon, namely, the duplication of the "canals" on Mars.

"Canals" is a very unfortunate word, for the markings, so called, may not be water at all, and, at any rate, they are too broad to bear any analogy to canals on the earth. However, Professor Schiaparelli has repeatedly seen these "canals," which were ordinarily single, duplicated—paralleled—by similar markings. So that his map is crossed in every direction by sets of parallel streets—the canals in question.

The opposition of Mars took place this year on April 11, and the months of March, April, and May were the favorable ones for the study of its surface. The observatory was officially completed on June 1, but it was not until July 16 that regular observations of Mars could be undertaken. Since that time more than forty careful drawings have been made at the large telescope by Mr. Schaeberle, Mr. Keeler, and myself. These drawings were made when the planet's diameter was less than 9 seconds, when its zenith distance was more than 60 degrees, and in the early evenings before the object glass had the time to cool down to the temperature of external air—that is, our work was done under conditions as unfavorable as possible. Still the drawings show a great amount of detail, are consistent among themselves, and all agree in showing single broad streaks of dusky marking which cover the regions where Professor Schiaparelli gives two parallel dark canals with a bright region between them. It would be a very simple explanation of the difference in our observations to say that the Lick telescope was lacking in defining power. But our observations of hundreds of difficult double stars, of nebulæ, and of the surface of Jupiter quite dispose of that alternative. It appears to me that so far as the question of the double canals is concerned, we must wait until the next opposition in 1890 to obtain entirely satisfactory evidence from our own observations.

We have, however, obtained satisfactory evidence on another point of equal importance relating to the surface of Mars, in spite of the late beginning of our observations. I refer to M. Perrotin's announcement of the submergence of the "continent" Libya, in April last. Writing to the Paris Academy of Sciences, M. Perrotin, the director of the great observatory at Nice, speaks first of the canals on Mars (some of which he was able to see doubled), and then goes on to say that of the modifications on the surface of Mars, the most important is "the disappearance of a continent which extended on both sides of the equator in longitude 270 degrees (the continent Libya of M. Schiaparelli's map). This continent is of a triangular form, and is bounded on the south and west by a sea, and on the north and east by canals. Although plainly visible two years ago, it exists no longer. The neighboring sea (if sea it is) has totally submerged it. To the reddish white color of the continents has succeeded the black or rather deep blue hue of the seas of Mars."

I do not know the exact date of these observations, but I presume them to have been made in April and early May of this year, since they were printed by the Paris Academy on May 14. They have been made the basis of far-reaching speculations. For instance, we read in the French journal *L'Astronomie* for July, 1888, that "important occurrences from the climatological, meteorological—and, perhaps, 'human'—point of view are just now taking place on the surface of this neighboring world"—and much more of the same kind. From the scientific journals this news has gone into the newspaper press and into current information. A hundred visitors to the Lick Observatory have inquired if these changes on Mars were observed here, and have been deeply disappointed when they have learned that our observations do not agree with those just quoted.

In fact, out of the forty drawings which we have been able to secure since July 16, no less than eight represent the continent Libya in its accustomed place, just as it was portrayed by M. Schiaparelli in 1877–8, not to speak of many later drawings by others. In fact, drawings by Mr. D. Smart, of London, on May 7, and by M. Flammarion, of Paris, on June 2, have recently been published, and help to fill up the history of Libya from the date of M. Perrotin's announcement to the date of our first observations. Both of these drawings show Libya in its accustomed state—well out of the water of the neighboring sea. If it really had been "submerged" in April and had really emerged by May 7, this would have been indeed a singular fact. But it seems to me that these astounding revelations of even "human" import have their basis in a confusion of terms. Who knows that the continent Libya is a continent at all? Who knows that the neighboring parts are really "seas" and canals? We know that Mars has aqueous vapor in its atmosphere; but who has yet decided which part of its variegated surface furnishes this by evaporation?

Suppose that the region viewed by M. Perrotin had been simply under clouds for a certain period. Might they not have produced the change in color which he undoubtedly observed? However, we may account for the appearances before the beginning of May, it seems clear from our own observations that this "continent" has remained in its normal state from July 16 until now, and the drawings of Flammarion and Smart seem to show that it was so in early May and in early June.

Scientific men are often blamed for not putting their observations before the public promptly. They usually defend themselves by quoting such cases as this, and by pointing out the harm that is done science when sensationalism creeps in, and wrong or hasty conclusions are drawn and run their course of error around the world. It appears that there is still something to be said in favor of an early communication by the scientific men themselves. But as they realize the danger of misinterpretation of their observations, they will, or should, be careful to give them in sober words which cannot be exaggerated or misunderstood.

To return to the case in point, it seems that our observations clearly show that Libya does still exist—just as it has in the past. And it is a reasonable inference that the obscurations observed by M. Perrotin were something in the nature of veiling by clouds, rather than the terrific catastrophe of the submergence of a continent.

Our observations upon the nebulæ in the last five weeks have been most interesting and important. The power of the great telescope is nowhere better shown than in reviewing objects which are familiar in other great and small telescopes and by the drawings and descriptions of Lassell, Herschel, and Lord Rosse. The nebula in Lyra, known to all possessors of small and large telescopes, has not only showed us new features and many new and minute stars within it, but it has also afforded by the critical situations and arrangements of these stars new proofs that the force which formed this nebula was a central force. If we please, we may assume that this force was gravitation; if this step is too hazardous (and it certainly is not proved for any nebula), we can with certainty say that this particular nebula, with its ovals of stars and nebulous matter, was formed by the action of central forces.

Other well-known nebulæ have afforded striking and interesting features which it is difficult to describe without the aid of illustrations. One in particular has seemed to be of especial import. I refer to the planetary nebula 37 H. iv. Draconis. Mr. Schaeberle and myself have observed this on many occasions, and it seems to be the first representative of a new class of objects—a class of nebulæ where the nebulous matter appears to be, and very probably, in fact, is, arranged in the form of a helix or screw, just as if the nebulæ had been formed by one brilliant particle revolving around the central star and leaving a brilliant train, while the central star itself was rapidly moving through space.

Sir William Herschel was the first to enumerate and to classify the nebulæ. Lord Rosse's giant reflector resolved many of Herschel's nebulæ into stars, while many others remain unresolved. The spectroscope appears to have shown that many of these last are truly gaseous. Lord Rosse added a new class of highly interesting nebulæ, namely, those whose parts were disposed in spirals on the flat ground of the sky. It appears to us that in this planetary nebula of Herschel's we have the first example of still another new class, in which the parts, at least, appear to be disposed in the form of a helix. Several other nebulæ already examined show evidences of the same form, and it is more than likely that other perfect examples of the class can be found

There are many large telescopes in America which will easily show this structure, and we hope they may be turned on this object. I add the remark that the focus for the central star (which is yellowish), and for the nebula (which is blue), are not quite the same, and that the helical forms are best seen when the focus for the star is changed slightly. (For Clark telescopes about 1–2000 to 1–1000 of the focal length.)

Our observations of Jupiter have been much interrupted by the necessity of observing Mars, and of photographing the moon at the most favorable hours for viewing this planet. Still we have seen enough to know that much yet remains to be done here.

Mr. Burnham has also utilized the hours when the telescope was not in use for other purposes by discovering new binary stars. He has already a list of some twenty or more such, all with distances not over one second of arc. Perhaps the most interesting of these is Gamma Cassiopeæ, a star of the second magnitude, with a most minute companion close within the rays, not two seconds off. It is in a favorable situation at present, and will be a fine test for the largest telescopes.

With the twelve-inch telescope Mr. Barnard has discovered some twenty or more new nebulæ, mostly very faint, and has made several series of observations on the comets of Faye, Encke, Brooks, Sawerthal, and Olbers. Mr. Barnard's observations of the Olbers comet are especially important, as they are more than a month later than any others of which we have heard, and thus will serve to determine the orbit of this famous comet with a high degree of precision. One of the chief services of the Lick Observatory to the science will be in utilizing its splendid equipment and its beautifully clear skies in observations of faint and difficult objects which are lost elsewhere. I have not spoken of several other series of observations which have been made within the few weeks of our astronomical activity, because of their more technical nature; but I have, I trust, given an account of our work sufficiently in detail to show that the Lick Observatory will fulfill the design of its generous founder, and will in fact be, as he prescribed that it should be, "useful in promoting science."—*N. Y. Tribune.*

THE RATTLE OF THE RATTLESNAKE.

By SAMUEL GARMAN.

THE habit of sloughing is common to all serpents. A short time before the removal takes place, the new epiderm makes its appearance beneath the old. Its presence is easily detected by a whitish color under the outer layer. The milky tint of the second layer extends over the whole body; on the eyeball it interferes greatly with the sight. During the time of its formation, several weeks, while the vision is affected, the snake prefers seclusion, and is disinclined to partake of food. Some days before casting, about a week in the most recent case followed, the milkiness vanishes, the skin resumes its ordinary aspect, and the sight becomes again as keen as formerly. By rubbing the lips the slough is loosened around the mouth, then it is pushed over the head to the neck, whence it is taken back over the body. From the neck backward it is, in some cases, removed by means of a coil or two of the tail, the body being crowded through and the epiderm left behind. A hole in the ground or between rocks, the sticks in a brush heap or the stalks in the grass, answer the same purpose as the ring made by the tail. Some manage to get the coat back until under the ventral scales, when the latter are used somewhat as in gliding, their free hinder edges catching and stripping off the slough as the body is moved slowly forward. From the hinder part of the body the removal is an easier matter: the loosened portion is caught around a stick or under a stone, and with a pull the balance is taken off in an instant. The slough comes away like damp paper; it is wet with a sticky mucus on the inner side, turned outward in the operation. The mode of growth and of removal are similar among the rattlesnakes. These snakes differ in retaining a portion of each slough, that covering the tip of the tail, to form one of the rings of the rattle. The attachment is purely mechanical; the rings are merely the sloughs of the end of the tail.

On the majority of the snakes, both the venomous and the non-venomous, the tail tapers more or less gradually to a point. At the end it is protected by a subconical cap of the epiderm. Under the latter lies the skin, and under it again the termination of the vertebral column—a bone formed of vertebræ that have coalesced and changed their shape until the outlines of the mass nearly resemble those of the surface of the tip. This terminal bone is hard externally, and cellular within; it contains and protects the extremities of the cord and vessels of the column in the positions occupied by them in the embryo before the consolidation was effected. In the different species the number of vertebræ included in this bone varies considerably; sometimes, also, it is seen to vary in individuals of the same species. Before the appearance of the scale-like folds on the tail of the embryo, the skin of the extremity is smooth; afterward, on some, the tip takes on the semblance of being protected on the sides by scales, the distal portions of which have blended with the cap, while their bases have remained distinct, much as if the conical envelope were still undergoing process of enlargement. In such cases the line of demarkation between the scales and the cap is irregular and indistinct. This condition obtains in species of Tropidonotus, Eutænia, Nerodia, and allies. The line of separation is very decided and regular in Crotalus. As the tail develops more slowly, the scales do not appear on it until after they are well formed on the body. Up to the time of their formation, the story of the caudal development of the rattlesnake is the same as that of any other serpent. The general shapes and the numbers of vertebræ differ greatly in the various kinds, but the history is similar in all. With the purpose of indicating the manner of growth of the rattle, and, as far as may be, of determining its origin, we shall have to follow it up through different species, a complete series of any one of them not being at hand.

SISTRURUS, Garm. Figs. 1–4.

Crotalophorus, Gray, not of Linné.

S. miliarius, Linn., is the only rattlesnake of which we have a good series of the very early embryos. Some of these, already three inches in length, are not yet furnished with scales on the tail, though the entire body is well provided. Outwardly, in these specimens, the tail is short, thick, blunt, slightly compressed, and has no indication of the characteristic feature so prominent after birth. The vertebræ are separate.

Figs. 1 and 2 of the diagrams are drawn from embryos of *S. catenatus*, Raf. (*Crotalus tergeminus*, Say), six and a quarter inches in length. Their only promise of the rattle is to be noted in the shape and size of the cap, or button. Upon the body the scales are perfect; the button evidently is incomplete, being little more than half of what it ultimately becomes.

If a button as it is at birth were to be cut through the constriction immediately behind the anterior swelling, the hinder portion would correspond with the cap as seen in Figs. 1 and 2. There is no evidence of any fusion of scales with the button around its front border. Except in case of the button, there is externally very little difference between this stage and the next represented. Within the cap the vertebræ are distinct, slightly smaller than those just in front of them, like the latter surrounded by muscles, and the skin is thicker than elsewhere. Between this stage and the following the anterior portion of the cap appears to be added by backward growth at the front margin, like that which later in life displaces the older button to make way for the new.

Figs. 3 and 4 are drawn from young ones of the same species, *S. catenatus*, Raf., eight and a quarter inches in length, about a week after birth. In them the button has been perfected, the cap having gained, as compared with Fig. 2, all the portion anterior to the constriction. On several of these specimens there is a tendency to fusion and irregularity among the scales immediately in front of the button, but in no case is there any disposition on the part of the scales to fuse with the latter. A portion of the button corresponding to the externally visible part of each ring has been acquired, while the entire length has increased a couple of inches, in a short time just before birth. Inside of the button the changes have been greater: the vertebræ, still plainly outlined, have consolidated into a single elongate mass, the size of which is being increased by both lateral and terminal growth; the vertical processes have grown together; and the muscles have been displaced by the enlarging bone and the thickening skin. Muscular command of the individual vertebræ within the button has been lost in the consolidation, but the muscles of the tail retain a firm hold on the mass, and the loss finds compensation in a better means of agitating the rattle. For later stages we are compelled to turn to a closely allied genus.

CROTALUS, Linné.

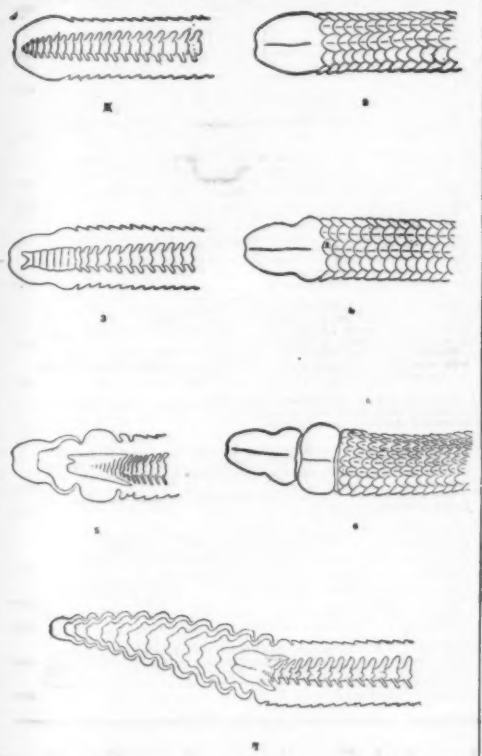
Crotalophorus, Linn.; *Caudisona*, Laur.

Figs. 5 and 6, from a *Crotalus confluentus*, Say, fourteen inches in length, show a considerable advance from the preceding. The specimen was taken, with the third button about half grown, when the process of pushing back the second ring was well under way. The first ring had been set free with the first slough, holding only by the collar; and if the snake had been allowed to live a little longer, the second sloughing would have discovered the third button perfected, clasped by the second ring, the latter pushed back and loosened from the balance of the epiderm. Of the second ring, the narrower posterior extension is quite empty; its anterior chambers are closely filled with the tumid skin, the loss of the ring being prevented in this manner, while the outer swelling of the new button is crowding it backward. A considerable shrinkage of the skin takes place after the moult; it is insufficient to allow the ring to slip off, though admitting of great freedom of motion. In front of the border of the second ring, Fig. 5, lies the fold, shrunken by alcohol in the specimen, by which the ring was displaced, and which was to become the largest chamber of the next succeeding. This fold is usually hidden by the epiderm attached to the ring, as in Fig. 6, until the operation of sloughing has been finished. The mass of bone occupies the place of eight or more of the vertebræ in this stage, the lines of separation being still noticeable to some extent. By a longitudinal section the cord and vessels are disclosed in their original positions, surrounded now by spongy bone, in which the cavities radiate from the center toward the surfaces. On the upper and lower faces there is less indication of the composition.

Figs. 7 and 8 were taken from a large specimen of *Crotalus horridus*, Linn. In it the traces of the vertebræ in the terminal bone are almost obliterated; the

bone has thickened, pushed forward at the edges, and otherwise enlarged. Along with this there has been an excessive development of the muscles of the tail. The rattle is entire, of eleven rings and a button. The hinder seven of the rings belong to the period of the snake's most rapid growth; they form the "tapering rattle" common to the young individuals, formerly used in classification of the species by some authors. Four of the rings and the button pertain to a part of the creature's life in which the gain in size was much less rapid: they form the "parallelogramic rattle" of the same writers. The mistaken use of these features in specific diagnoses no doubt arose from study of incomplete rattles. The change from the taper to the more nearly parallelogramic takes place about the seventh ring—in *Sistrurus miliarius* often with the sixth, with the larger species frequently with the eighth—and affords the means of obtaining an approximate idea of the comparative age of the owner of the series of rings. The figures show the rattle as commonly held by the snake when crawling. In a single series of rings there is much variation in shapes, as in sizes, and there are also considerable differences in the rattles within the species. In the case of the small snake *Crotalus exsul*, Garm., from Cedros Island, Lower California, the large size of the first ring is evidence of derivation from a larger species, probably *C. lucifer*, B. & G., of the mainland. In this case, the change in button has not kept pace with the reduction in size of body, or the changes in squamation, etc. While the rings vary with rapidity of growth in the body, from amount of food, it is unlikely that it makes any difference in their number, or that of the sloughings.

More than seventy specimens have been looked over for evidence of growth of a new button between the months of May and September; two, and a doubtful third, favor the conclusion that a ring is added in the fall. One of these, as it was in September, is sketched in Figs. 5 and 6. On the other hand, living specimens kept through the winter prove that a new growth does take place toward spring, and that when the epi-



Figs. 1, 2. Sistrurus catenatus. 4 times nat.
3, 4. Sistrurus catenatus. 3½ times nat.
5, 6. Crotalus confluentus. 3 times nat.
7. Crotalus horridus. Nat. size.

derm is shed, on coming out of winter quarters, the animal is possessed of an addition to the rattle.

The mechanism of the organ has been so often described and figured that it is unnecessary to give a detailed description here. Among the most accurate of the earlier writers is Lacépède, 1789 (Histoire des Serpens, II., pp. 390–420, Pl. XVIII.); and of the more recent, Czermak, 1857 (Ueber den schallerzeugenden Apparat von Crotalus, in Vol. XIII. of the Zeitschrift für wissenschaftliche Zoologie, pp. 294–303, Pl. XII.) For comparison with what has been recorded above, a few sentences are quoted from Lacépède (p. 404). Speaking of the mode of growth, he says: "Quand une pièce est formée, il se produit au-dessous une nouvelle pièce entièrement semblable à l'ancienne, et qui tend à la détacher de l'extrémité de la queue. L'ancienne pièce ne se sépare pas cependant tout-à-fait du corps du serpent; elle est seulement repoussée en arrière; elle laisse entre son bord et la peau de la queue, un intervalle occupé par le premier bourlet de la nouvelle pièce; mais elle enveloppe toujours le second et le troisième bourlets de cette nouvelle pièce, et elle joue librement autour de ces bourlets qui la retiennent. . . . Si les dernières vertèbres de la queue n'ont pas grossi pendent que la sonnette s'est formée, chaque pièce qui s'est moulée sur ces vertèbres a le même diamètre; et la sonnette paroit d'une égale largeur jusqu'à la pièce qui la termine; si, au contraire, les vertèbres ont pris de l'accroissement pendant la formation de la sonnette, les bourlets de la nouvelle pièce sont plus grands que ceux de la pièce plus ancienne, et la diamètre de la sonnette diminue vers la pointe."

The anatomy of Crotalus was studied by Tyson in 1683 (Philosophical Transactions, No. 144).

In regard to the use of the rattle there is not much to be said. Mainly, it is used to warn off disturbers, and thus prevent useless expenditure of venom. Success in capture of food depends on an ever ready supply of poison. To secrete a new lot takes time. The rattle is used also in breeding season, though it is doubtful if the dull-eared creatures depend on sound, rather than scent, to find their mates. A theory advocated by some maintains that the organ is used in imitating insects, to draw the birds. An objection to this is the fact that birds are somewhat rarely found in stomachs of the Crotali. An obervation appearing to favor this theory was made on a Dakota snake, found braced up among the branches of a sage bush in such a way that the head overlooked the surrounding bushes, while the tail, within the mass of branchlets, was free to keep up the rattling that attracted the attention of a party more than fifty yards distant. But the approach of the troop may have occasioned the creature's peculiar behavior.

ORIGIN OF THE RATTLE.

Many serpents besides those possessed of a crepitaculum are addicted to making a rattling noise by vibrations of the end of the tail. It is likely the modifications of the organ apparent in some or others of these are consequences of this habit. In illustration of the extent to which the tail has been modified in different cases, apparently for similar purpose, attention is directed to Figs. 9–14, from species allied to the rattlesnakes.

Rhinocerophis ammodytoides, Leybold, Figs. 9, 10, from the Argentine Confederation, has its most prominent distinguishing features in a prominence on the top of the snout, and, of more importance in this writing, a peculiar termination of the tail. Fig. 9 outlines the caudal surface. The terminal piece is sub-crescentic in longitudinal vertical section and sub-round in transverse. Externally it is covered by the horny skin, internally it is bony. On the top, two of the dorsal scales reach back more than a third of the length, and near their tips fuse with each other and the skin about them. Fig. 10 shows the arrangement after the skin and muscles have been removed. The outside of the bone is hard, the inside not solid. It is penetrated by the canals of the vertebræ—indications of its origin. Inferiorily, it extends forward below three of the vertebræ, firmly anchylosed to it and to each other, the anterior of the three being partly subtended. In front of it, the column is normal. Each vertebra is long, low, rather broad, and vertically crossed in the middle by a light line, as if two had joined end to end. The neural spines are low, inclined backward, and, in the hinder three or four, expanded laterally on the upper edge into a flange that in the posterior unites with the terminal bone. Zygapophyses and parapophyses are feebly developed; the hypapophyses are blade-like, thin and fragile. Appearances suggest that the tip is carried upon and struck against the ground.

On *Lachesis mutus*, Linn., Fig. 11, from Brazil and northern South America, the end of the tail is a long, slender, compressed, cultriform blade. The scales in front of it are small and tubercular. This is especially the case with a dozen or more of the sub-caudals, that, as they approach the end, are subdivided and spine-like. Within the cap the bone is similar to those described above. The vertebræ preceding it are slender, with weak processes. Near the extremity the tail is slender and very flexible—a condition enhanced by the smallness of the scales. It looks as if it were carried off the surface.

Halys acutus, Gth., Fig. 12, is a serpent recently described by Dr. Gunther, 1888 (Ann. Mag. Nat. Hist., (6). I., 171, Pl. XII.), from the mountains north of Kiu Kiang, China. It is remarkable on account of a flexible pointed lobe extended from the end of the snout, and for the peculiar scutellation of its compressed tail. Dr. Gunther says the tail is not to be in any way taken as an initial step in the development of the rattle of Crotalus, though the organ in this species may in a much smaller degree exercise the same function as in the rattlesnake, being an instrument by which vibrations and sound are produced. From what we have seen above, it is not difficult to imagine a rattle developed from the arrangement of scales and vertebræ present in this snake. However, as Dr. Gunther remarks, and as illustrated below, it is quite unnecessary to suppose the tail of Crotalus has gone through such modification.

Ancistrodon piscivorus, Holbr., Fig. 13, the moccasin, from the southern United States, is similar to Rhinocerophis in the structure of the tip. The terminal bone is not so greatly developed. A greater number of scales have fused with the cap.

On *Ancistrodon contortrix*, Linn., Fig. 14, the copperhead, of the United States to Mexico, the tip differs a little from that of its congener, the moccasin. It is directed downward as well as backward. Most often the cap, or button, has one or two swellings in a degree resembling those on a ring of the rattle. A living specimen of this snake, kept for a year or more, would take to rattling on the floor whenever he was irritated. The sound was made by the terminal inch of the tail, this part being swung from side to side in the segment of a circle, so that the tip might strike downward. The result was a tolerable imitation of that made by a small rattlesnake

Both copperhead and moccasin bear evidence of union between cap and scales. All the specimens have two scales fused above and two below the button. Some show that more have joined the two above, and that one or more of the laterals has been included on the sides.

The testimony of the embryo is to the effect that the rattlesnakes were derived from forms in which the terminal vertebræ were not fused into a terminal bone. There seems to be no radical difference in the earlier stages of the end of the tail, between the above mentioned as well as other non-crotalophorus forms and Crotalus. So much divergence in the number and shape of the caudal vertebræ occurs in the various genera, that these features become matters of secondary interest in a general comparison. In the later development the rattlesnake goes farther than any of the others. The bone at the end of the column is of the same nature throughout the Ophidia. On Crotalus it eventually contains a greater number of vertebræ, there is a greater enlargement of the mass, and in devoting it exclusively to shaking the rattle, instead of striking upon objects, a different use is made of it. In front of the rattle the neural spines incline forward, possibly a consequence of the function of the tail. This inclination has little weight when compared with forms like Ancistrodon, where the spine is so low. Similar leaning toward the head occurs in the Hydrophidæ and in Ogmophis, a Tertiary fossil of uncertain affinity. So far as the vertebræ are concerned, they point to no special one of the recent allies as representative of the stock from which the rattlesnakes have sprung.

With the button there is but little more success. While it might possibly have been formed or enlarged by fusion of scales with the cap, there is really no reason to suppose scales were formed on the end of the tail only to be lost again. In fact, embryonic data favor the conclusion that it was formed by simple enlargement, or expansion of the cap itself. A cap that by its shape would be mechanically held to its successor might be produced by slight changes in that of any one of a number of species of the family, in addition to those figured. Shape is the important feature in the retention of the series of caps. This, in the rattlers, is obtained through that of the end bone, the thick skin covering the latter, and the mode of growth. Generally, on the pointed tip there is no chance to retain the cap during and after the slough. Without the backward growth from the front border at the time of forming the cap, again, the rattle would not exist, as each new cap would be formed entirely within its predecessor. *Ancistrodon contortrix*, the copperhead, Fig. 14, gives a hint of the probable manner of origin of the rattle, in the folds, or swellings, at the front border of the cap. The presence of these folds apparently indicates that growth from the margin has taken place. If, as seems to be the case from the folds, the necessary manner of growing already exists, but a slight increase in it, increasing the amount of the swellings and constrictions, would be needed to provide the copperhead with a rattle. After the retention of the displaced cap was secured, the change from the habit of striking the tip upon the ground to simple shaking would be followed by loss of flexibility in the tail itself, by rigidity of the column—a condition, with inclusion in the cap and the peculiar strain on the muscles, favoring consolidation of the terminal vertebræ, and tending to draw the spines forward. It ap-

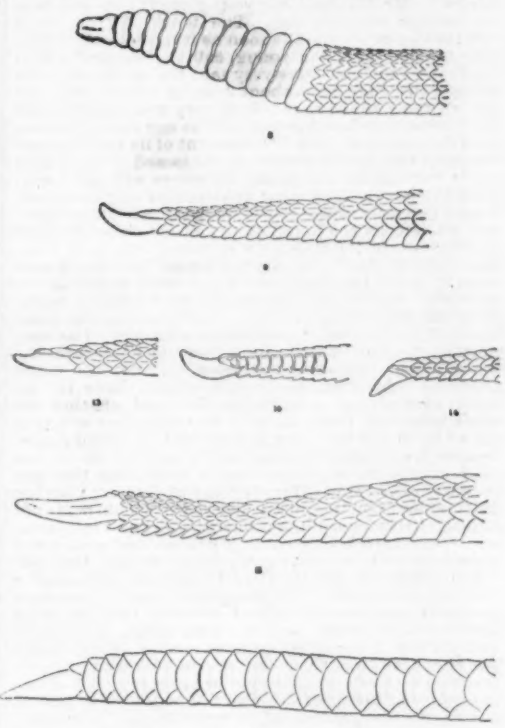


Fig. 8. Crotalus horridus. Nat. size.
9, 10. Rhinocerophis ammodytoides. 2½ times nat.
11. Lachesis mutus. 3 times nat.
12. Halys acutus. After Günther.
13. Ancistrodon piscivorus. 2 times nat.
14. Ancistrodon contortrix. 2½ times nat.

pears very much as if the rattle originated in some such way.

Though the copperhead has been specially used as an illustration here, it is not asserted that the rattlesnakes are directly derived from it. Taking the general characteristics into consideration, it seems more likely they took origin in several stocks; one of them, allied rather closely to Ancistrodon, yielding the Sistruri (the small rattlesnakes with large crown shields); another, nearer to Lachesis, giving rise to *Crotalus durissus* and allies.

In summarizing, we may say the rattlesnakes have probably been derived from members of the same family that had no rattle. The button of the rattle was formed by enlargement of the terminal cap covering the terminal bone, very likely without fusion with scales. The shape of the button was determined by that of the bone and skin of the tip; it is modified in the second and following rings by the ring immediately preceding. The exterior or exposed part of each button after the first is formed in front of the ring with which it is in contact, and pushes the latter back. As the button is displaced to become a ring, it is prevented from passing entirely off by the swollen skin, completely filling its anterior chambers, behind the constrictions. The development of the button and the rattle was accompanied by a consolidation and compacting of a larger number of the vertebræ, with loss of the muscles directly belonging to the reduced portion, and with greater development of the muscles in front of it. And, finally, the probability that the rattlesnakes represent at least two lines of descent may be added; one, that of Sistrurus, more closely connected with the copperheads; another, that of *Crotalus durissus* and allies, connecting with that of *Lachesis mutus*.—*Harvard College Bulletin of the Museum of Comparative Zoology.*

THE POISONOUS SNAKES OF THE BOMBAY PRESIDENCY.

AT a recent meeting of the Bombay Natural History Society a paper was read by the honorary secretary, MR. H. M. PHIPSON, on the "Poisonous Snakes of the Bombay Presidency." He produced for inspection specimens of the following poisonous snakes, all of them having been killed in the Presidency of Bombay:

Colubrine.—1, *Ophiophagus elaps;* 2, *Naga tripudians;* 3, *Bungarus arcuatus;* 4, *Callophis trimaculatus*, 5, *Callophis nigrescens.*

Viperine.—6, *Daboia elegans;* 7, *Echis carinata;* 8, *Trimeresurus anamallensis;* 9, *Hypnale nepa.*

With regard to the first species, the *Ophiophagus elaps*, it is perhaps the largest poisonous snake in the world, sometimes measuring over 15 ft. It is also called the "king cobra" or "hamadryad," and is not very common, though widely diffused, being found in the Andamans, the Philippines, Borneo, Java, and Sumatra. On account of expanding a "hood," it is frequently mistaken for the cobra, but the head shields of the hamadryad differ very much from those of the cobra. The second species, *Naga tripudians*, or cobra, is found all over India, and up to the height of 8,000 feet in the Himalayas. There are many varieties, differing in color and marking, to which the natives give different names, thinking them distinct species; but in such matters the native knowledge is not very extensive. Thus they believe that all the hooded cobras are females, and that the males are harmless. What they call the male is in reality only the common Indian rat snake (*Ptyas mucosus*). They also state that the rat snake is proof against the poison of the cobra. But this is not the case. Last year the young ones hatched in the society's rooms attacked a small Malay python put into their cage, when they were only a few days old, and bit at it viciously, and the python died in a few hours after its removal to another cage. Once a year, during the rainy season, the cobra lays from twelve to twenty eggs. In one specimen, shown by Mr. Phipson, the young one is seen just as it is emerging from the egg. The tooth with which it cuts its way out is shed as soon as it has served its purpose. When born, the young cobras measured about 7½ inches long, and were very fat; but at the end of a few months they were about 9 in. in length, but had lost all their plumpness. It is very remarkable that the original nutriment got out of the egg should be able to sustain them so long. On account of its timidity and the great ease with which it can be tamed, it is the only snake with which the snake charmers will have anything to do. By attracting its attention with one hand, it may be easily seized round the body with the other; and so long as the hand or any other object is kept moving before its eyes, it will never turn to bite the hand that holds it. This is the simple fact the knowledge of which the charmers turn to such advantage in their well known performances. The snake is taken from its basket, and a slight stroke across the back brings it at once into a defensive attitude. The constant motion of the musical instrument before the snake keeps it watchful and erect, and not the music produced. As a matter of fact, snakes have no external ears, and it is extremely doubtful whether the cobra hears the music at all. The charmers say that the adder of the East, the *Daboia*, has no ear for music, because they cannot operate on it as they do on the cobra. It is rather interesting to note that this has been the belief since David's time at least: "Like the deaf adder that stoppeth her ear; which will not hearken to the voice of charmers." 3. The krait (*Bungarus arcuatus*) is an exceedingly poisonous snake, and is quite common in nearly every part of India. One specimen taken in the Bombay Presidency contained a "brown tree snake" (*Dipsas gokool*), and in another specimen was found a *Ptyas mucosus*, thus showing that this species eats snakes. The common *Lycodon aulicus*, one of the non-poisonous snakes, is very much like the krait, but they can be distinguished by the presence in the krait of large hexagonal scales down the center of the back. 4. The *Callophis trimaculatus* has no popular name. It is undoubtedly poisonous, and lives on other snakes, very likely the Calamariæ. 5. *Callophis nigrescens*, which grows to about 4 ft. in length, is black in the upper parts and red in the lower.

6. The first class of the Viperine snakes is the *Daboia elegans*, called by Europeans in India the chhin viper and in Ceylon the tic polonga. The fangs are very long, and for this reason, together with its fierceness, it is the most dreaded snake in India. Its poison acts differently from that of the cobra. Its tenacity of life is really wonderful, it having been known to live for a whole year without food. The length of this snake rarely exceeds 5 ft. 7. The *Echis carinata* and the last named class are the only true vipers in India. The harmless "brown tree snake" (*Dipsas gokool*) is frequently confused with the *Echis carinata*, but they are easily distinguished by the scales on the head of the latter, while the *Dipsas gokool* has plates or shields. 8. The green tree viper *Trimeresurus anamallensis*) is one of the family of Crotalidæ or pit vipers, so named from the pit or cavity beneath the eye and the nostril, of which family the terrible rattlesnake of America is a member. In India there are eight species of Trimeresuri, but up to the present only one has been found in Bombay, though it has been stated that another species, *T. strigatus*, has been seen far up the country. 9. The headquarters of the *Hypnale nepa*, or carawala, are in Ceylon, but it is commonly found along the Malabar coast.

These classes include all the poisonous land snakes. All the true sea snakes are poisonous, and of these, among others, the following are in the Bombay collection: *Hydrophis diadema, Hydrophis robusta, Hydrophis curta, Hydrophis aurifasciatus, Hydrophis Phipsoni, Hydrophis Guntheri, Hydrophis Lindsayi, Hydrophis chloris, Enrhydrina bengalensis, Pelamis bicolor.*—*Nature.*

DETECTION OF FAHLBERG'S SACCHARINE IN ARTICLES OF FOOD.

A SENSITIVE reaction may be founded upon an observation communicated by Prof. Ira Remsen in the *American Chemical Journal*. On heating ortho-sulphobenzoic acid with resorcine and sulphuric acid, there is formed a compound analogous to fluorescein. A small quantity of saccharine heated with a slight excess of resorcine and a few drops of strong sulphuric acid in a test tube turns yellow, red, and then dark green, gives off sulphurous acid in plenty, and enters into vigorous ebullition, which continues for a short time after the removal of the flame. This ebullition is reproduced twice more and the liquid is let cool, diluted with water, and supersaturated with alkali, yielding a solution reddish by transmitted light, and displaying a strong green fluorescence by reflected light. This fluorescence is so sensitive that in presence of 0·001 gramme saccharine the liquid can be diluted to 5 to 6 liters without the recognition of the fluorescence being in the least interfered with. The saccharine is best extracted from articles of food by means of ether. Solids and sparingly soluble substances are pulverized, moistened with a few c. c. of dilute sulphuric or phosphoric acid, dried, and exhausted by shaking with ether in a closed vessel. Fatty matter, if present, must first be removed by treatment with petroleum ether.—*E. Bornstein.*

THE OIL OF THE SEEDS OF JATROPHA CURCAS.

THIS oil is now (*Chemiker Zeitung*) used for burning, soap making, adulterating olive oil, and probably for the preparation of alizarin oil. It is distinguished from castor oil by being almost insoluble in alcohol, by its lower specific gravity, and by its higher saponification and iodine number.—*F. M. Horn.*

A New Catalogue of Valuable Papers

Contained in SCIENTIFIC AMERICAN SUPPLEMENT during the past ten years, sent *free of charge* to any address. MUNN & CO., 361 Broadway, New York.

THE SCIENTIFIC AMERICAN Architects and Builders Edition.

$2.50 a Year. Single Copies, 25 cts.

This is a Special Edition of the SCIENTIFIC AMERICAN, issued monthly—on the first day of the month. Each number contains about forty large quarto pages, equal to about two hundred ordinary book pages, forming, practically, a large and splendid **Magazine of Architecture**, richly adorned with *elegant plates in colors* and with fine engravings, illustrating the most interesting examples of modern Architectural Construction and allied subjects.

A special feature is the presentation in each number of a variety of the latest and best plans for private residences, city and country, including those of very moderate cost as well as the more expensive. Drawings in perspective and in color are given, together with full Plans, Specifications, Costs, Bills of Estimate, and Sheets of Details.

No other building paper contains so many plans, details, and specifications regularly presented as the SCIENTIFIC AMERICAN. Hundreds of dwellings have already been erected on the various plans we have issued during the past year, and many others are in process of construction.

Architects, Builders, and Owners will find this work valuable in furnishing fresh and useful suggestions. All who contemplate building or improving homes, or erecting structures of any kind, have before them in this work an almost *endless series of the latest and best examples* from which to make selections, thus saving time and money.

Many other subjects, including Sewerage, Piping, Lighting, Warming, Ventilating, Decorating, Laying out of Grounds, etc., are illustrated. An extensive Compendium of Manufacturers' Announcements is also given, in which the most reliable and approved Building Materials, Goods, Machines, Tools, and Appliances are described and illustrated, with addresses of the makers, etc.

The fullness, richness, cheapness, and convenience of this work have won for it the **Largest Circulation** of any Architectural publication in the world.

MUNN & CO., Publishers,
361 Broadway, New York.

A Catalogue of valuable books on Architecture, Building, Carpentry, Masonry, Heating, Warming, Lighting, Ventilation, and all branches of industry pertaining to the art of Building, is supplied free of charge, sent to any address.

Building Plans and Specifications.

In connection with the publication of the BUILDING EDITION of the SCIENTIFIC AMERICAN, Messrs. Munn & Co. furnish plans and specifications for buildings of every kind, including Churches, Schools, Stores, Dwellings, Carriage Houses, Barns, etc.

In this work they are assisted by able and experienced architects. Full plans, details, and specifications for the various buildings illustrated in this paper can be supplied.

Those who contemplate building, or who wish to alter, improve, extend, or add to existing buildings, whether wings, porches, bay windows, or attic rooms, are invited to communicate with the undersigned. Our work extends to all parts of the country. Estimates, plans, and drawings promptly prepared. Terms moderate. Address

MUNN & CO., 361 BROADWAY, NEW YORK.

THE

Scientific American Supplement.

PUBLISHED WEEKLY.

Terms of Subscription, $5 a year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,
361 Broadway, New York, N. Y.

TABLE OF CONTENTS.

PAGE

I. ASTRONOMY.—The Lick Observatory.—By EDWARD S. HOLDEN.—A graphic account of the work in progress, and prospect for the astronomers of the great observatory 10627

II. BIOGRAPHY.—George Rogers Clark.—A hero of the Revolution, capturer of the Governor General of Canada, and eldest brother of the explorer.—Note of his exploits in the Revolutionary war... 10616

III. CHEMISTRY.—Detection of Fahlberg's Saccharine in Articles of Food.—A sensitive reaction for detecting this substance, the new sugar substitute 10630
The Oil of the Seeds of Jatropha Curcas.—A new adulterant of olive oil and other substances, and a method for its detection..... 10630

IV. CIVIL ENGINEERING.—Four Hundred Miles in Eight Hours.—The record of the fastest train service in the world, recently established in England.—Accurate details of its speed..... 10619
The Hydraulic Elevator at Les Fontinettes.—The greatest hydraulic work in France.—A canal boat elevator of 300 tons capacity.—2 illustrations 10616
Timber and Some of its Diseases.—By H. MARSHALL WARD.—Continuation of this contribution to constructive science, treating of growing timber from seed and the troubles encountered therein.—4 illustrations..... 10626

V. ELECTRICITY.—Description of an Underground Conduit.—By ALEXANDER CRAWFORD CHENOWETH.—A new method of forming such a structure described.—5 illustrations..... 10624
Electro-Chemical Radiophone.—Note on an interesting experiment in thermophony..... 10621
Electrical Conductivity of Metals..... 10624
The Practical Applications of Electricity.—By WILLIAM HENRY PREECE, F.R.S.—A recapitulation of scientific work of the day in the realm of electricity.—The presidential address in the electrical section at the British Association meeting.—A most important review of electrical progress of the day, touching on all its applications to practical life..... 10622

VI. MINING AND METALLURGY.—The Brittleness Induced in Iron by Pickling.—By Prof. A. LEDEBUR.—Abstract of a memoir of vital importance to the iron manufacturer, revealing a cause of weakness hitherto little known..... 10625
The Iron and Coal Mines of Alabama.—The Birmingham mines, with analyses of Alabama coal and coke.—A *resume* of the wealth of this portion of the "new South."—1 illustration..... 10625

VII. NAVAL TACTICS.—British Naval Maneuvers.—The blockade of Bantry Bay.—Note and illustrations of the practice evolutions executed there.—3 illustrations..... 10618

VIII. PHOTOGRAPHY.—Novel Magnesium Lamp and Reflector.—A contribution to photography, designed to obviate the defects usually incident to this source of photographic illumination.—3 illustrations 10631
Restoring Faded Photo-prints.—A prize process for restoring faded albumen prints..... 10631

IX. TECHNOLOGY.—Beet Sugar and its Industry.—By Prof. GUSTAV GEHRING.—A most exhaustive review by the chemist of the Missouri agricultural station of this industry and its possibilities for America..... 10629
Regenerative Furnaces for Small Gas Works.—A solution of a long-standing problem.—The economy of fuel in small establishments.—3 illustrations..... 10629
Retort Setting for Small Gas Works.—By J. ROBB.—How to set a bench of two retorts.—3 illustrations..... 10628

X. ZOOLOGY.—The Poisonous Snakes of the Bombay Presidency.—Abstract of a recent paper on this interesting zoological subject. 10630
The Rattle of the Rattlesnake.—By SAMUEL GARMAN.—A most valuable monograph on a subject comparatively little understood hitherto.—14 illustrations..... 10626

Useful Engineering Books

Manufacturers, Agriculturists, Chemists, Engineers, Mechanics, Builders, men of leisure, and professional men, of all classes, need good books in the line of their respective callings. Our post office department permits the transmission of books through the mails at very small cost. A comprehensive catalogue of useful books by different authors, on more than fifty different subjects, has recently been published, for free circulation, at the office of this paper. Subjects classified with names of author. Persons desiring a copy have only to ask for it, and it will be mailed to them. Address,

MUNN & CO., 361 Broadway, New York.

PATENTS.

In connection with the **Scientific American**, Messrs. MUNN & Co. are solicitors of American and Foreign Patents, have had 42 years' experience, and now have the largest establishment in the world. Patents are obtained on the best terms.

A special notice is made in the **Scientific American** of all inventions patented through this Agency, with the name and residence of the Patentee. By the immense circulation thus given, public attention is directed to the merits of the new patent, and sales or introduction often easily effected.

Any person who has made a new discovery or invention can ascertain, free of charge, whether a patent can probably be obtained, by writing to MUNN & CO.

We also send free our Hand Book about the Patent Laws, Patents, Caveats, Trade Marks, their costs, and how procured. Address

MUNN & CO.,
361 Broadway, New York.

Branch Office, 622 and 624 F St., Washington, D. C.